ANNUAL REPORT 2018-2019

For the year ended March 31, 2019

Railway Technical Research Institute

Foreword

Norimichi KUMAGAI
President of the Railway Technical Research Institute

Fiscal 2018 is the 4th year of RTRI's five-year master plan RESEARCH 2020. Assessing its progress accurately, we have been conducting research and development and other tasks in order to complete the master plan. Based upon the needs of railway operators and the rapid development of science and technologies, we have been dynamically promoting research and development in order to create the technologies that will lead the changing society and to provide quality outcomes.

In 2018, Japan suffered from many disasters by floods caused by torrential rainfalls, typhoons and earthquakes in Osaka and Hokkaido. RTRI provided railway operators with technical support in investigating the causes of railway accidents, disasters and equipment failures and in proposing measures to prevent operation disruptions as well as helped the investigations and restoration of operations in the disaster areas.

This fiscal year, we focused on the research topics for enhancing railway safety. In Japan, increasingly serious natural disasters such as earthquakes, torrential rainfalls, strong wind and heavy snowfalls have frequently occurred in recent years. RTRI has been developing measures to prevent derailment, level crossing accidents and human errors and developing condition monitoring technologies as well as the technologies to enhance the resilience against the serious natural disasters.

We have also promoted research and development to build low-cost, energy efficient and convenient railway systems, to raise Shinkansen's speed, and to further enhance simulation technologies. In implementing these research projects, RTRI has been seeking to extensively use information and communication technologies including advanced sensing technologies, image analysis using machine learning and high-speed large-capacity communication systems.

We have been increasing the number of researchers particularly in the fields of disaster-prevention measures, energy saving and the speed increase on Shinkansen. We have continued the construction of a new testing equipment for dynamic and electrical tests of pantograph and catenary for Shinkansen's speed increase, a new low-noise moving train model rig and a new high-speed wheelset testing facility to enhance running safety. Furthermore, we have started to construct a new building to accommodate these testing machines.

The ICT Innovation Project was also set up in order to determine the direction of the research into ICT and to establish an interdisciplinary research plan. Our supercomputer was replaced by a machine with five times faster processing speed.

We will continue to promote the research and development in order to enhance the value of railways and to be trusted by railway operators and other customers. Continued support and advice from all the rail-related people will be most appreciated.

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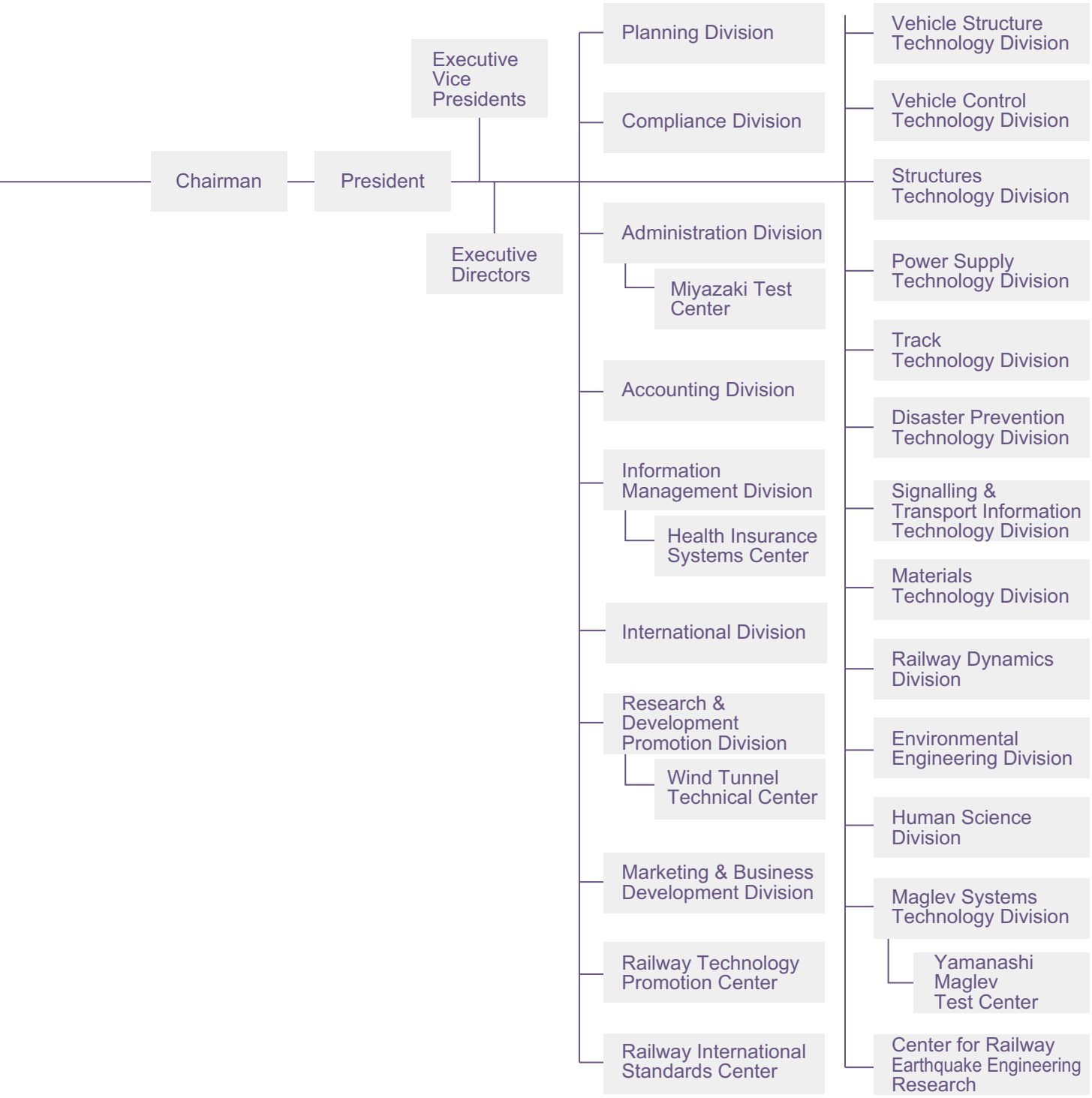


(As of April 1, 2019)

Major Results of Research and Development

IMPROVEMENT OF SAFETY

1. Real-time hazard mapping system for localized heavy rainfall-induced disasters

- This system analyzes natural hazards caused by localized heavy rainfall in real time, and calculates train stopping positions and evacuation routes for passengers to avoid hazard areas.
- This system can be used to support decisions on how to apply operational regulations currently in force in case of rainfall.

Countermeasures to natural disasters caused by heavy localized rain, depend on being able to forecast these hazards, and being able to adapt esponses over time. Being able to do this can help reduce damage and accelerate resumption of services following disruptions. The system presented uses constantly updated precipitation forecasts analyzed in real time based on third party data and identifies inundation of small to medium sized watersheds and large-scale landslides at a certain distance from railway, and then depending on the outcome of these analyses shows suitable stopping locations for trains or passenger evacuation routes.

The developed system includes 4 sub-systems (Fig. 1): ①A system for converting random-points precipitation into graphs based on two-hour precipitation forecast data received approximately every ten minutes from external sources; ② A system which conducts sequential analysis of inundation hazards; ③ A system for displaying hazards when forecast precipitation reaches a given threshold in areas that have previously been identified as possible locations of large-scale landslides; ④ A system for displaying locations for trains to stop to avoid the hazard, and possible routes for passengers to take in the event of an evacuation.

This system can identify where natural disasters, inundations and large-scale landslides are likely to occur almost in real time, which can support operational decisions and determine evacuation routes and safe locations for passengers to flee to in the case of heavy localized rainfall, improving safety.

In addition, the system can prove useful for prior examination of equipment inspection periods and locations, to enable faster resumption of operations.

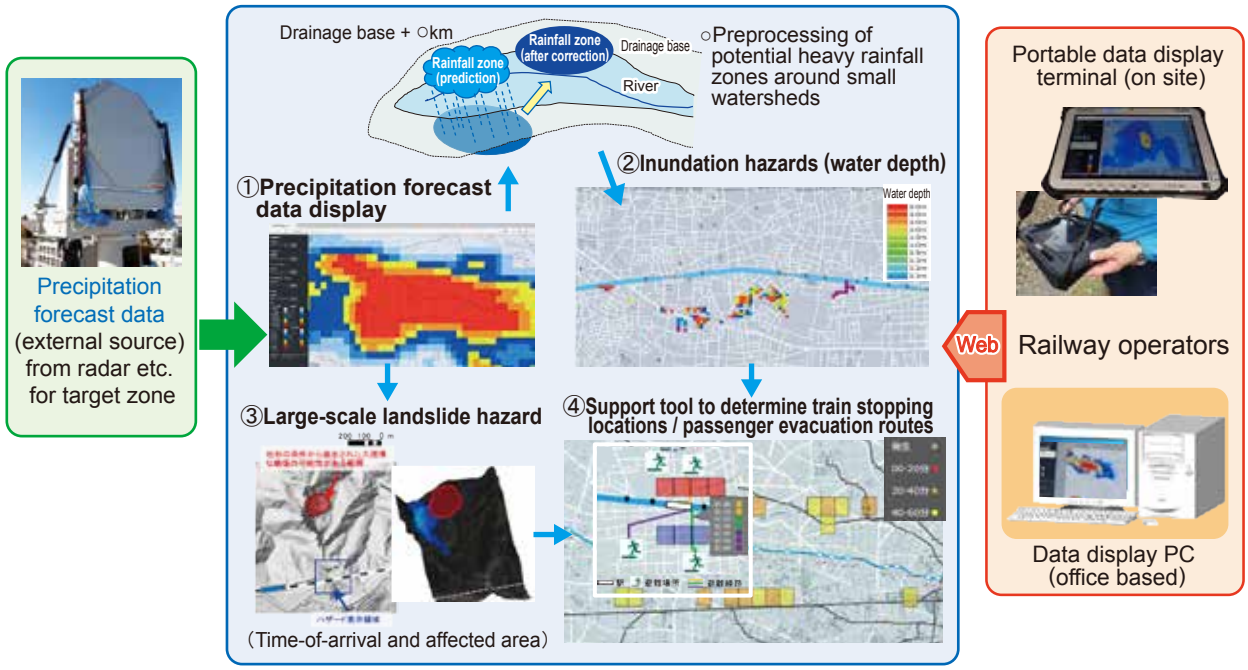


Fig. 1 Railway disaster mitigation system against heavy localized rainfall, etc., based on forecast precipitation data

2. Earthing system testing device for lightning protection in power supply installations

- A new portable testing device has been developed to inspect earthing systems in fixed power supply installations.
- The newly developed testing device makes it possible to perform a lightning protection testing with a faster current rise than conventional testing devices.
- The automatic data processing function in the developed device allows operators without special skills to carry out tests.

Lightning protection tests (high frequency) of earthing systems in fixed power supply installations cannot be carried out using ordinary earthing resistance tests (low frequency) because of the difference in frequency components of the testing currents. The current waveform of a lighting strike typically surges rapidly as shown in Fig. 1. Since lightning is a natural phenomenon, the surge time is random. However conventional test results using simulated lightning currents surging in few microseconds were insufficient for the protection of ICT control equipment in fixed power supply installations, because ICT equipment is more vulnerable to lighting strikes than earlier relay-based control equipment.

Consequently, a new portable testing device for earthing system inspection was developed as shown in Fig. 2. A new developed power source circuit optimized for earthing system testing was installed into the device. Compared to the conventional equipment the circuit can generate a simulated lightning current with a faster surge in about 0.2 μs (blue curve in Fig. 1). The new testing device can be used to evaluated lighting protection covering the 95th percentile of lightning strikes, according to reported statistics 1).

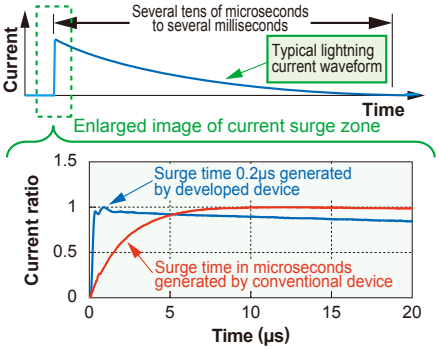


Fig. 1 Testing device current waveform

Furthermore, an automatic data processing function including an algorithm to calculate the evaluation value (earthing impedance) was developed and installed into the new testing device. The function allows operators, such as railway maintenance workers, to carry out tests without the need for special skills.

Table 1 shows the test results from two substation earthing systems on a railway line in operation. According to the results, compared to conventional devices, the developed device can evaluate conditions that are 3 to 10 times more critical. The developed device can therefore be used for regular inspections, for detecting potential weaknesses in installations, and verifying the effect of earthing system designs in order to improve protection against lightning, etc.

Table 1 Example of results from an evaluation of an installation in operation

Conditions	Soil	Evaluation value	
		Conventional device	Developed device
Substation A	Dry	4.7Ω	42Ω
Substation B	Damp	9.6Ω	37Ω

〔Reference〕
1) Lightning Protection for Electrical and Electronic Equipment, Institute of Electrical Installation Engineers of Japan, OHMSHA, 2011

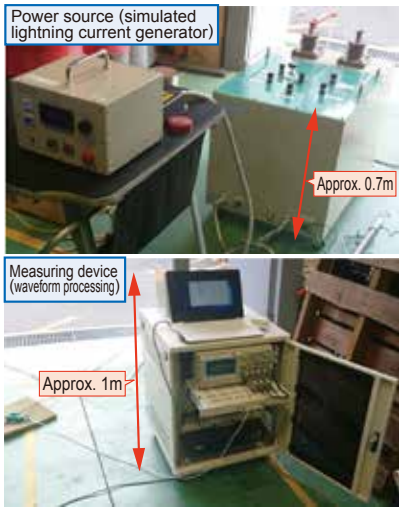


Fig. 2 Developed earthing system testing device

3. Vertical damper to suppress decrease in wheel load on container wagon bogies

- In order to suppress the decrease in wheel load on container wagons, improvements were made to a vertical bogie damper.
- Stationary vibration tests on a rolling stock test rig were performed on a single container wagon, simulating actual cross-level track irregularity, confirming that the improved damper was able to suppress wheel-unloading by approximately 20%.

When a carbody rolls due to track irregularity, there is a decrease in wheel load. This can become a factor leading to derailment in the case of container wagons. Consequently, the vertical damper on the bogie was improved.

On container wagon bogies, vertical dampers are mounted in parallel with secondary suspension to manage the switch in attenuation characteristics between the loaded and empty state of the wagon.

However, depending on the load conditions, etc., even if the mass including the load corresponds to empty vehicle damper characteristics, there are cases where rolling can easily occur.

In such cases, if the vibration frequency caused by continuous irregularity at a constant wavelength and the natural frequency of the vehicle rolling coincide, resonance can occur, and the more rigid the secondary suspension, the greater the relative attenuation force insufficiency of the damper, causing a cyclical decrease in wheel load.

Investigations were carried out using dynamic vehicle simulation, to examine the attenuation characteristics of compliant dampers under different loading conditions, from empty to maximum loaded state. As a result, an improved damper was proposed for vehicles with relatively rigid springs, excluding empty state attenuation properties, corresponding to unified loaded state characteristics which strengthened the attenuation force in the operating speed region below 10cm/s (Fig. 1).

Fig. 2 Vibration tests on rolling stock test plant

In order to confirm the effect of the improved dampers, stationary vibration tests were performed on a container wagon on a rolling stock test plant (Fig. 2). Cross-level irregularity track measurement data was input to the roller rig, to reproduce in a test, the conditions that led to the past derailment. As a result, when the speed of roller rig was 60 km/h, it was found that the improved damper had lowered the wheel-load reduction ratio on the third axle by approximately 20% (Fig. 3).

Following main line running tests to confirm the validity of the new design with different loading conditions, a proposal will be made to introduce the improved damper into service as a way to improve the operating safety of freight wagons.

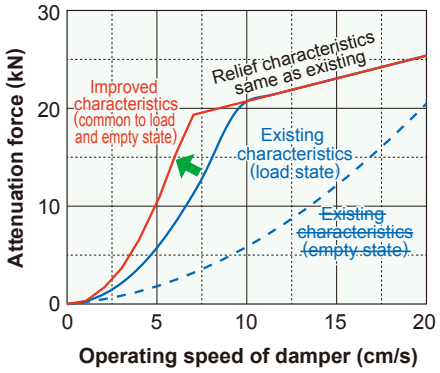


Fig. 1 Attenuation force characteristics of the vertical damper

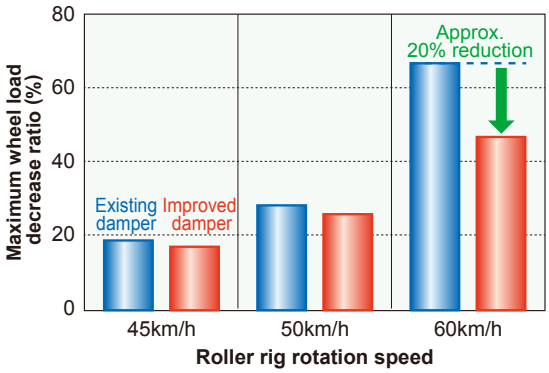


Fig.3 Effect of suppressing decrease in wheel load using the improved damper

4. Seismic reinforcement methods for improving anti-catastrophe performance of railway viaducts

- A work method has been proposed to improve anti-catastrophe performance of railway viaducts against unexpectedly extreme earthquakes.
- A dead-weight compensation structure was developed to prevent the collapse of viaducts.
- A structure to control the direction of collapse and failure behaviour of a viaduct, is developed to help rapid repair.

Railway structures are built according to seismic design requirements to guarantee safety and durability. However, it is impossible to say that in future they will not be subject to unexpectedly powerful earthquakes. Consequently, a dead-weight compensation structure and collapsing-direction control structure were developed in order to increase the seismic resistance of new and existing viaducts.

The dead-weight compensation structure ensures that even if a viaduct's piers are temporarily destroyed, a back-up set of piers (dead-weight compensation columns) come into play to support the vertical load of the viaduct slabs, thereby preventing total collapse (Fig. 1).

The tops of the dead weight compensation columns are equipped with a Teflon slipping surface, severing the connection with the viaduct and horizontal movement. Consequently, the structure protects the piers from damage due to inertial force, and they are able to support the vertical load of the slabs. The results of loading tests confirmed that the structure with dead-weight compensation columns prevented the collapse of the viaduct even when its piers were severely damaged by the shaking (Fig. 2).

Were the viaduct to collapse, the collapse-direction control structure artificially controls the fall direction, thereby protecting adjacent residential areas and emergency access roads, etc. (Fig. 3). As shown in Fig. 3, a block-shaped device has been introduced to prevent the structure from collapsing in the undesirable direction. Results from shaking table tests confirmed that the direction of fall (to the right) could be controlled when subjected to vibrations equivalent to over twice the current level required in seismic design (Fig. 4).

In addition to these large-scale tests, design methods for applying the proposed methods to real structures were proposed, based on a response analysis methods, resilience evaluation method, and design method, etc.

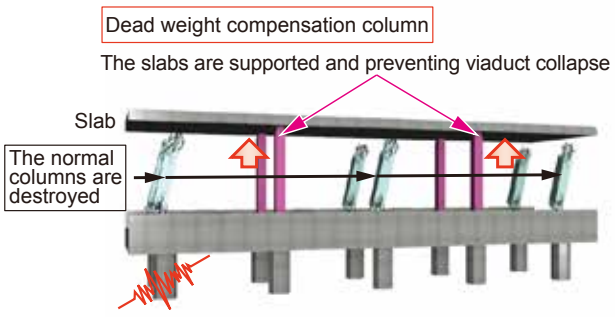


Fig. 1 Dead-weight compensation structure

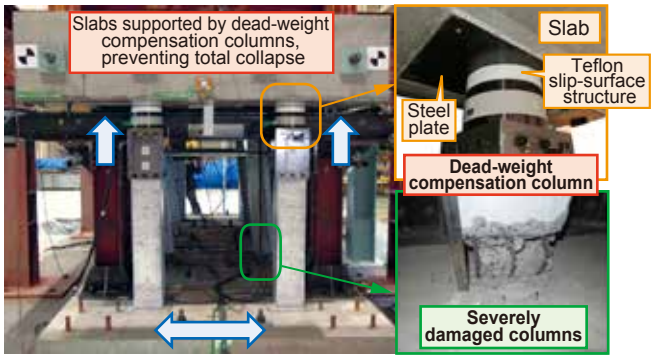


Fig. 2 Effect of dead weight compensation structure in shaking table tests

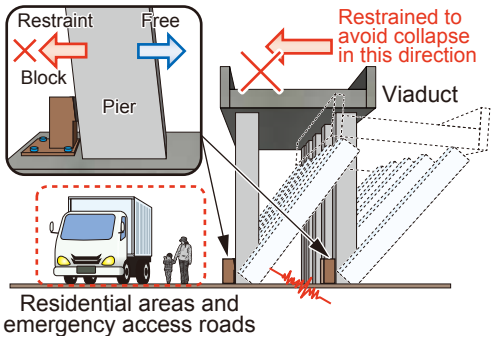


Fig. 3 Schematic outline of the collapse-direction control structure

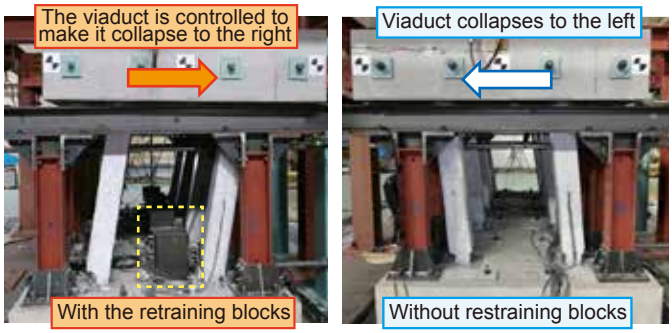


Fig. 4 Effect of collapse-direction control structure in shaking table tests

5. Support System for verifying evacuation safety in case of station fire

- A system for verifying evacuation safety was developed to make it possible to keep a real-time visual track of the state of smoke propagation and passenger evacuation, in case of a station fire.
- The system makes it possible to verify evacuation safety based on distribution of the estimated number of people being evacuated, based on station characteristics.
- It also makes it possible to verify evacuation safety considering the effect of evacuation instructions broadcast over PA (public address) systems.

Design specifications in building standards are determined on the basis of maximum distances to emergency exits, etc., which can be used to evaluate the safety of evacuation in case of a fire in a station. However, the objects of these specifications are often offices and other such spaces in stations. Generally, they do not consider stations as a whole. Consequently, a support system was developed as a tool to verify the safety of station evacuation measures when being designed, by predicting passenger flows (evacuation times) and movement of smoke (time for smoke layer to descend) (Fig 1).

A new calculation formula was created for estimating the number of people that need to be evacuated from the station concourse, which is needed for calculating evacuation time. The estimation formula was created using passenger flow surveys that were carried out in 5 stations of different size and layout. Using the input variables of concourse surface area, number of station users, number of lines of movement, etc., the formula gives the density of people that need to be evacuated per section of station concourse.

As a result, using this formula dispenses with the need to conduct on-site surveys to obtain a setting for the number of people that need to be evacuated, and it is possible to reproduce their distribution in the station when a fire breaks out (Fig. 1).

In addition, employing the existing PA system in the station used for assisting evacuation, tests were conducted to examine the effectiveness of different sound broadcasting methods to guide people out of the station (Fig. 2). The effectiveness of instructions given through the different broadcasts was integrated into the system. Based on this integration, it should be possible to investigate the effectiveness of different types of evacuation guidance to shorten overall evacuation time (Fig. 3).

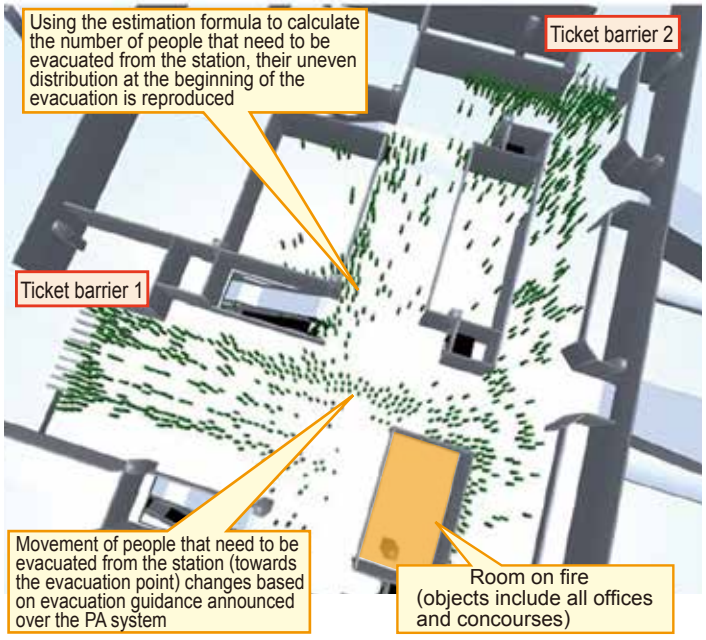


Fig. 1 Example of system output (initial distribution of people that need to be evacuated from the station)

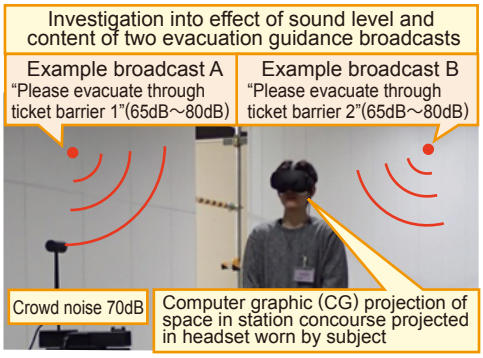


Fig. 2 Evacuation guidance experiment conducted with healthy subject

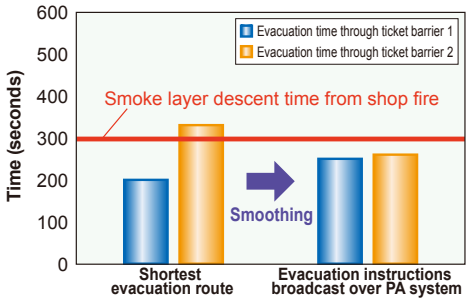


Fig. 3 Effect of evacuation instructions

6. Early railway line tsunami inundation forecasting method

- A method was developed to give early estimations of inundated areas and water depth along railway lines due to tsunamis, using tsunami data from the open sea transmitted from public institutions.
- Using data from the 2011 off the Pacific coast of Tohoku Earthquake, it was confirmed that it was possible to obtain early estimations of inundated areas with an accuracy of over 90% approximately one hour before the time the tsunami would have made landfall.

In order to accurately estimate the water depth of inundations caused by a tsunami immediately after an earthquake, it would be effective to develop a method that uses tsunami data from the open sea transmitted from public institutions. Consequently, tsunami data from the National Research Institute for Earth Science and Disaster Resilience and the results of a previously conducted tsunami simulation were used to develop an early tsunami inundation forecasting method.

In step 1 of this method (Fig. 1), using tsunami data observed at one station out at sea and a previously prepared tsunami propagation function obtained through numerical simulation of a tsunami, an estimation is made of the expected tsunami height at the coastline. In step 2, using inundation maps for various earthquake scenarios collected in a database, the inland inundation area matching the estimated coastline tsunami height is extracted. This method therefore has the unique feature of being able to improve not only the timeliness of warnings using data from a single observation station, but can also increase the impact on stability of the warnings by building databases of tsunami propagation functions and inundation maps ahead of time.

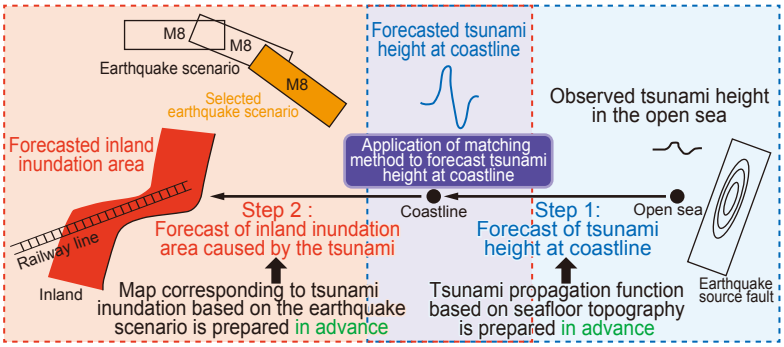


Fig.1 Inland early tsunami inundation forecasting method

Applying this method to data from the 2011 off the Pacific coast of Tohoku Earthquake, and comparing the subsequent inundation areas with those from the model issued by the Japanese Cabinet Office as an accurate reference, it was confirmed that both areas matched by over 90% (Fig. 2). By the same measure, it was also confirmed that the water depth of inundations caused by the tsunami could be estimated approximately one hour before reaching the railway tracks.

Applying this method immediately after receiving tsunami data observed in the open sea, and by displaying the water depth of inundations caused by the tsunami around the tracks, it would be possible to communicate to trains ahead of the flooding, which sections of track they could move to in order to remain safe for evacuation (Fig.3).

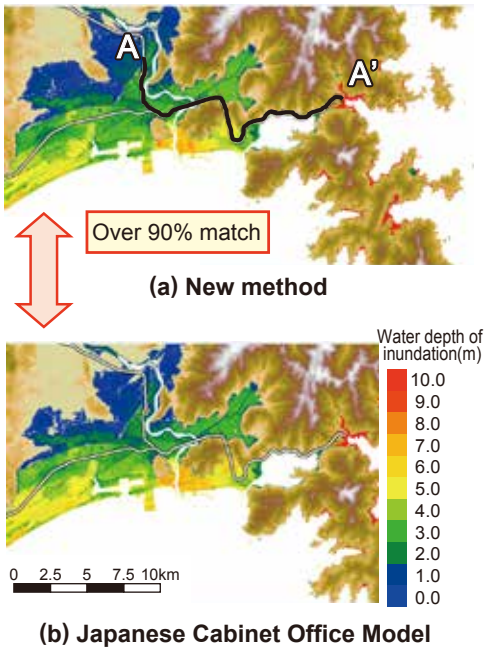


Fig. 2 Forecast accuracy of new method

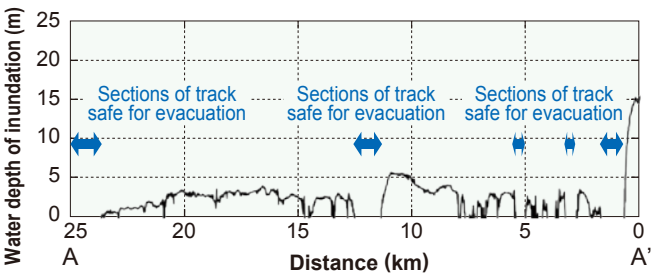


Fig. 3 Real time extraction of sections of track safe for evacuation along railway line on route A-A'

7. System for determining the stability of slopes during snow-melt season

- A system has been developed to determine the stability of slopes during snowmelt season using meteorological data.
- The system function without the need to install new observation equipment by using publicly available information.
- The new method was able to detect 20% more cases of slope stability deterioration compared to existing method.

A method has been developed to determine the stability of slopes during snowmelt season using the amount of snowmelt as an index.

In the existing method, the maximum amount of snowmelt in the area is used as a threshold for determining that slope stability has declined. However, in past geo-disasters, there have been cases where it was not possible to determine whether slope stability had declined. Therefore, a method has been proposed to determine slope stability using two indicators: the snowmelt volume and snow depth.

The new method uses observation data from AMeDAS and public geographical data in the vicinity of the target point to estimate the amount of snowmelt and snow depth in order to determine slope stability. Using AMeDAS data, past snowmelt volumes for each snow depth are then calculated and then set as threshold values. By comparing the threshold values with actual snowmelt volumes and snow depth calculated on the basis of AMeDAS data updated on an hourly basis, it is possible to determine the slope stability (Fig. 1). Taking past geo-disasters as a reference, the ratios of successfully detected deteriorated slopes (disaster detection rate) using the existing and newly developed methods were compared. The results of the comparison confirmed that even though results in both systems were the same in terms of the time in which the amount of snowmelt exceeded the threshold value, the newly developed method's disaster detection rate was approximately 20% higher than the existing method (Fig. 2).

Given that the new method only uses publicly available data and information, it allows the stability of any slope to be examined, without the need to install a new network of observation equipment. In addition, the system is designed so that if the system is used in an environment with internet access, the user can obtain a visual display of the slope stability result in any location, as shown in Fig. 1.

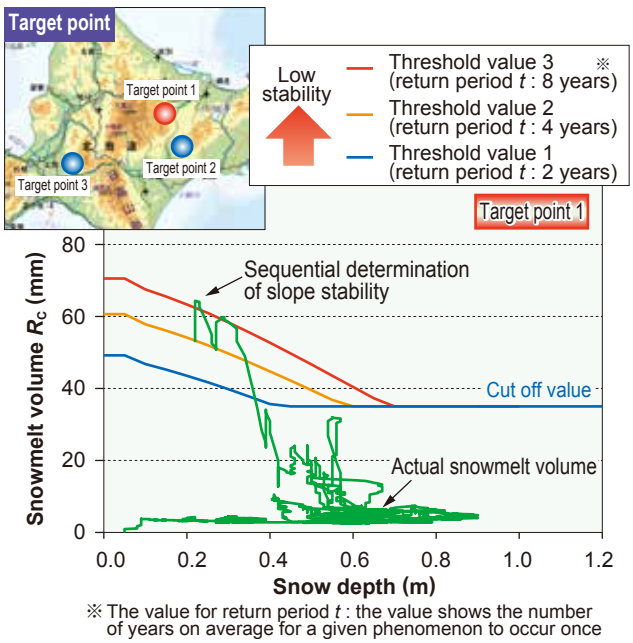


Fig. 1 Example of result of slope stability determination in snowmelt season (Target point 1)

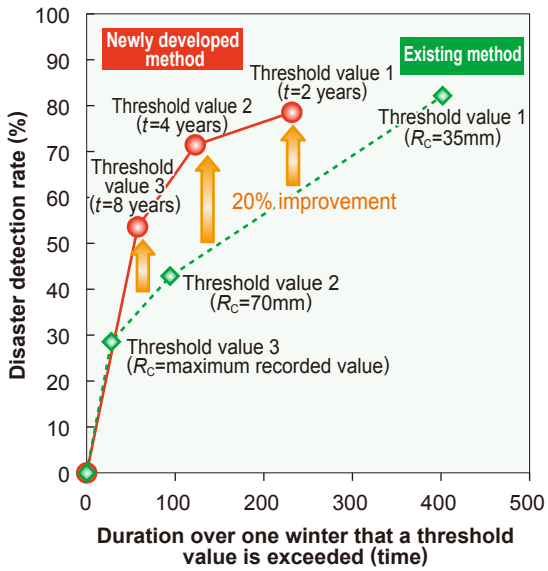


Fig. 2 Result of disaster detection rate comparison between newly developed method and existing method

8. Measures for reducing damage to overhead contact line system due to bridge oscillations caused by passing trains

- A computation method was developed to analyse coupled oscillation between bridges and catenary poles caused by passing trains, which also revealed the conditions under which overhead contact line system oscillations were largest.
- As a means to prevent wire fatigue failures in overhead contact line systems due to large bridge oscillations caused by passing trains, a new metal fitting was designed and a decision-making flow chart was proposed to determine whether measures had to be taken or not.

On some sections of simple-support bridges, wire fatigue failures in overhead contact line systems have occurred due to large bridge oscillations caused by passing trains. The amplitude of bridge and catenary pole oscillation depends on their type and design. Consequently, it is necessary to clarify what conditions of bridge and catenary pole lead to wire fatigue failure, and to identify the criteria that determine whether measures have to be taken or not.

A computation method of coupled oscillation between bridges and catenary poles (Fig. 1) was developed to be able to calculate their complex coupled oscillation. It was found that calculated response displacements coincided with measured values. This new computation method is therefore able to reveal the conditions that cause larger oscillations in overhead contact line systems. These results can be used to screen which existing bridges have conditions that are likely to cause wire fatigue failure, and to select which measures should be applied to prevent damage.

The total amplitude of catenary-pole displacement that causes wire fatigue failures was then clarified. When the total amplitude exceeds 50 mm, insulator rotation is restricted, resulting in a tremendous strain on the wire. Consequently, a new metal fitting was developed to reduce this strain (Fig. 2). In addition, a decision-making flow chart was proposed to determine whether measures had to be taken or not (Fig. 3).

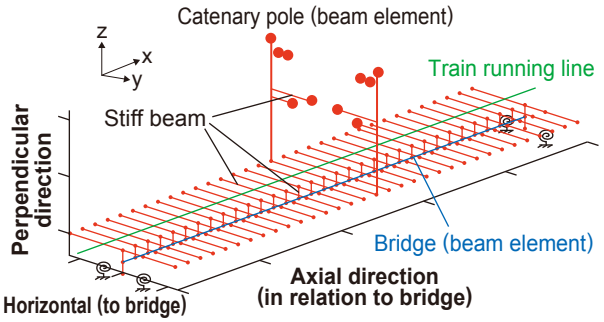


Fig. 1 Coupled oscillation model of catenary pole and bridge.

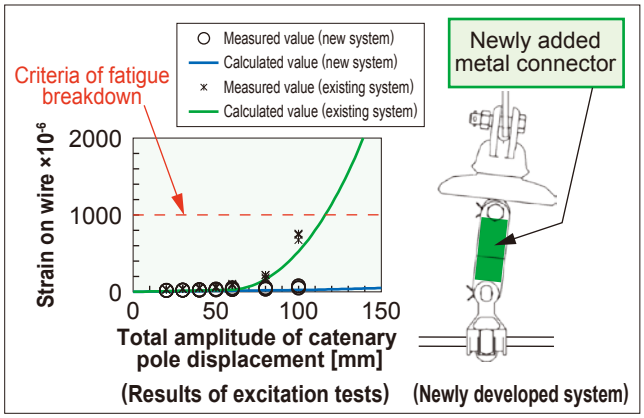


Fig. 2 Structure of wire support metal fitting to reduce strain on wire

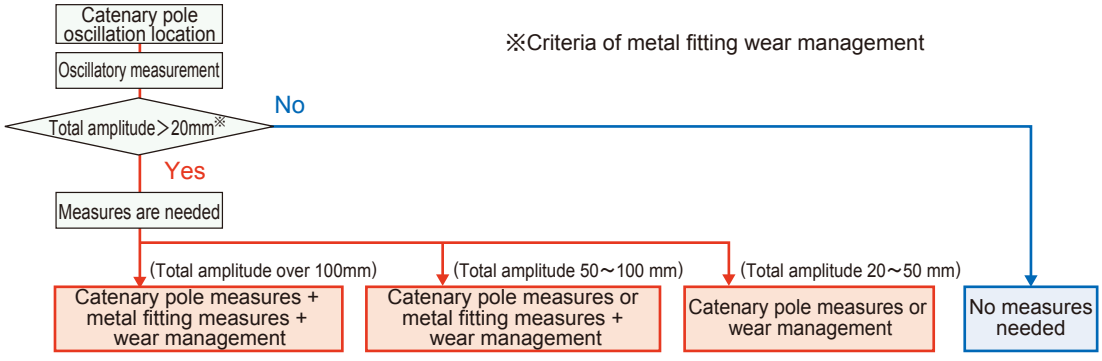


Fig. 3 Decision making flowchart about catenary pole oscillation whether measures need to be taken or not

9. VR-based training to prevent man-vehicle collision accidents

- A training method using virtual reality (VR) technology, was developed to teach railway personnel about the processes leading to man-vehicle collision accidents and the risks of working alongside tracks.
- Tests using the training method with on-site railway personnel led to a 21-point increase in the number of staff who followed rules completely.

There is a need to educate frontline railway personnel about the risks of violating rules, however, there has been a lack of clarity about exactly what risks should be highlighted during training.

After analyzing past cases involving track maintenance or work on electrical installations, and conducting opinion surveys among on-site railway personnel, it became clear that training was necessary in particular to understand the "processes leading up to accidents" in order to promote more rigorous rule keeping.

Consequently, a "VR experience-based training method" was developed to provide training on better understanding the processes leading to man-vehicle collision accidents (Fig. 1). The training method comprises two types of module, the "Virtual reality experience" and "Case transfer." The "VR experience" module is a role play exercise where the subject is given the role of the person in charge of a worksite. The subject is immersed in a VR scenario, where they can walk around a simulated space and participate in track maintenance work. One of the scenarios used raises awareness about the process that leads to a man-vehicle collision accident due to lack of attention to approaching trains when fully absorbed in a task: through the exercise, the subject is able to understand the importance of moving away from a track at the right time (Fig.2). The "Case transfer" part of the training, uses past cases as a reference. Subjects take part in a group discussion, and reflect on how the process leading to a man-vehicle collision accident could apply to their own workplace, and examine what tangible countermeasures could be implemented.

The "VR training method to prevent man-vehicle collision accidents" was trialed with a group of on-site personnel. The training improved their understanding about how man-vehicle collisions occur, and compared to before the training, the number of respondents who said they would fully comply with rules for moving away from tracks at the right time, rose by 21 points (Fig. 3).

The satisfaction level among participants was particularly high for the VR experience, with 96% of respondents agreeing that it was "true to reality."

It is hoped that implementing this training will increase level of compliance with rules that can prevent man-vehicle collision accidents.

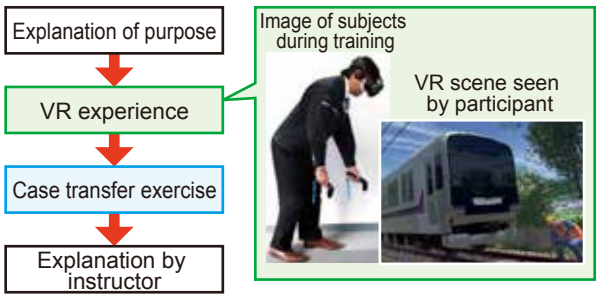


Fig. 1 Outline of "VR-based training method to prevent man-vehicle collision accidents"

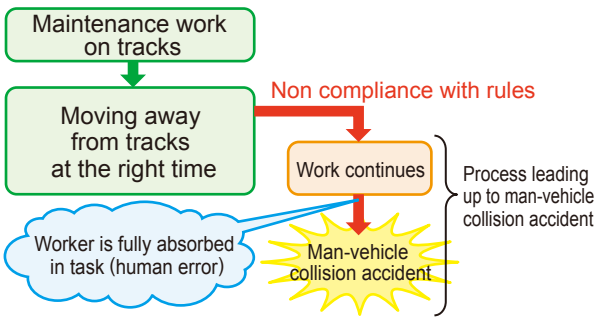


Fig. 2 Example of VR scenario

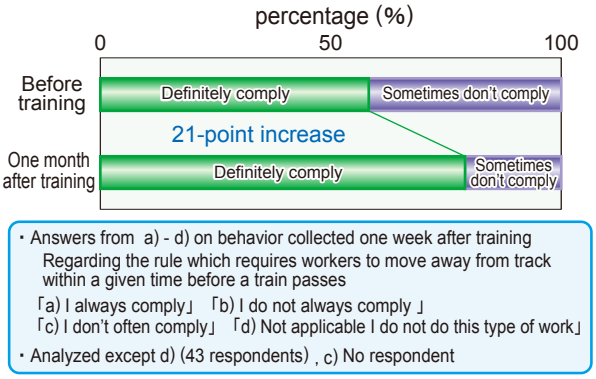


Fig.3 Rule compliance behavior before and after training

10. Method for evaluating train running safety during earthquakes considering non-linear behaviour of structures

- A method has been developed for evaluating the running safety of trains during earthquakes taking into account the non-linear behavior of structures.
- Using design drawings and specifications, the method is able to rapidly detect existing elevated bridges that present a weakness in terms of running safety during earthquakes, which can help selection of suitable countermeasures and prioritization of work.

As work progresses to implement measures against derailment or install derailment prevention guiding devices, there is a growing need to find a way to rapidly and accurately detect vulnerable sections of line on the network in terms of Shinkansen running safety during earthquakes.

The response of structures built according to old design standards, in some cases under L1 seismic motion fell into a non-linear domain, that was outside the scope of methods cited in existing design standards. This created the problem that detailed numerical analyses then needed to be performed which were both costly and time consuming.

Dynamic interaction analyses between vehicles and structures were therefore carried out, and a comprehensive investigation was made into the influence of various factors such as vehicle type, running speed, vibration characteristics of structures and type of earthquake, on derailment limits considering the non-linear behavior caused by the yielding of the structure. An evaluation method was then developed taking into account the coupled influence of structural vibration displacement (acceleration) and structural boundary differential displacement (angular rotation) (Fig. 1). The applicability of the new evaluation method was verified by comparing its output with results from the detailed numerical analysis.

The present method extends the scope of evaluation to non-linear domains that were beyond the area of application of the design standards. In addition, by using structural design drawings and specifications, it is possible to rapidly and accurately extract vulnerable sections, to support the selection of countermeasures and prioritization of work (Fig. 2).

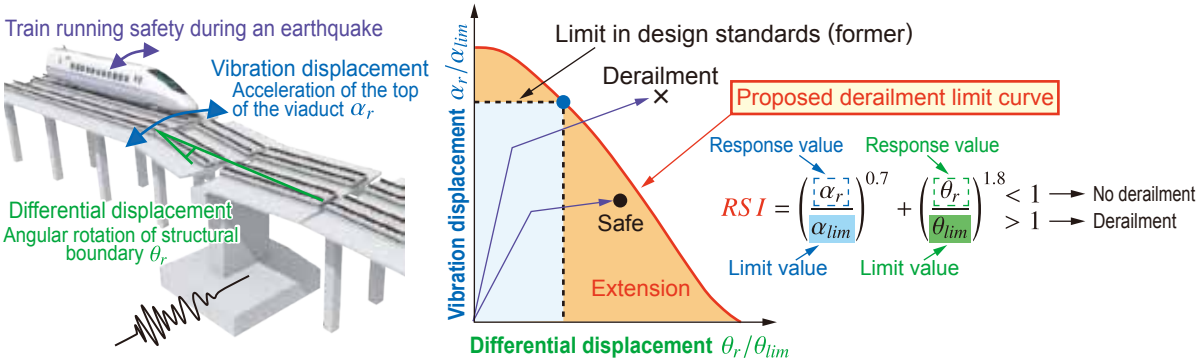


Fig. 1 Running safety evaluation method considering non-linear structural behavior

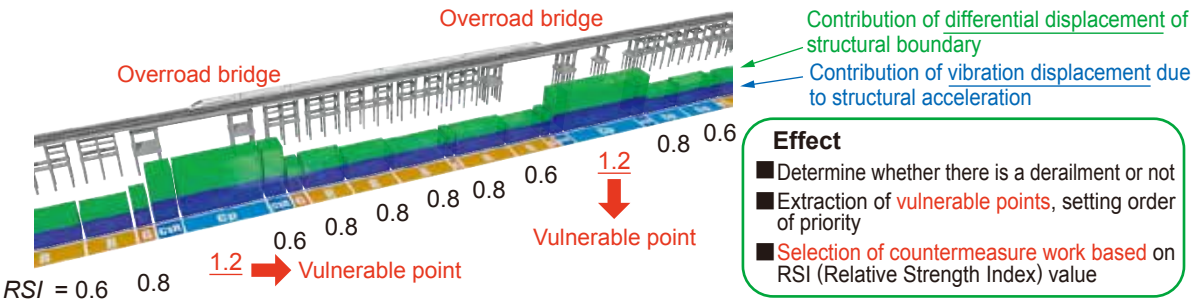


Fig. 2 Main effects and image of application of proposed method

11. Critical wind speed of overturning based on actual measured lateral vibration acceleration

- A method for calculating the critical wind speed of overturning with the use of measured lateral car-body vibrational acceleration values has been proposed, making it possible to evaluate the resistance to overturning in accordance with a train's actual running conditions.
- A stochastic interpretation of the critical wind speed of overturning following analysis of the frequency of occurrence of lateral car-body vibrations, will make it possible to add a safety margin to the evaluation of crosswind stability against overturning that reflects the assumed probability of occurrence.

The crosswind stability of railway vehicles against overturning can be evaluated from the critical wind speed of overturning. Using the detailed RTRI equation for calculating the critical wind speed of overturning, which takes into account not just vehicle and infrastructure specifications, but also many other factors, and based on a premise of the severest running conditions, including wind direction, lateral car-body vibration due to constantly changing track irregularity, it is possible to make safer evaluations. However, for train operators to use this method on a daily basis for train operations, it would be more practical if the evaluation reflected more real track and other trackside wind conditions.

Consequently, this research makes a proposal to apply actual measured lateral car-body vibrational values to the vibrational inertia term in the RTRI detailed equation. In this method, the existing assumption of the linear equation (in the RTRI detailed equation), is replaced with an adapted linear equation including the vibrational acceleration peak value of waveforms measured at different speeds (Fig. 1), resulting in some cases where the critical wind speed of overturning was calculated to be as high as 2-3 m/s (Fig. 2).

This method also allows stochastic interpretation of the critical wind speed of overturning following analysis of the frequency of occurrence of lateral car-body vibration (Fig. 3). Adopting a new annotation of results of the calculation of the critical wind speed of overturning which separates the average (deterministic) and fluctuating (stochastic) parts, it is possible to calculate the critical wind speed of overturning with quantitatively incorporated safety margins that reflect the assumed probability of occurrence. In turn, this makes it possible to take into account the balance required between safety and operational stability when setting wind speeds for operation control.

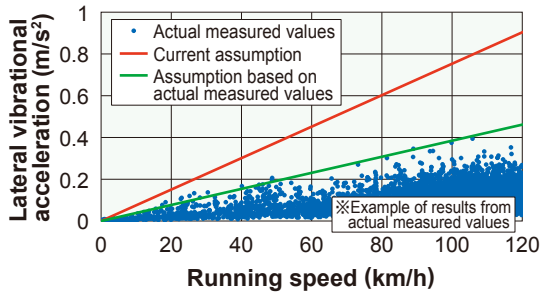


Fig. 1 Relationship between running speed and lateral vibrational acceleration

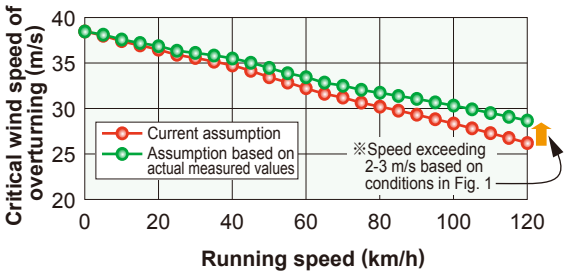


Fig. 2 Example of calculation of critical wind speed of overturning

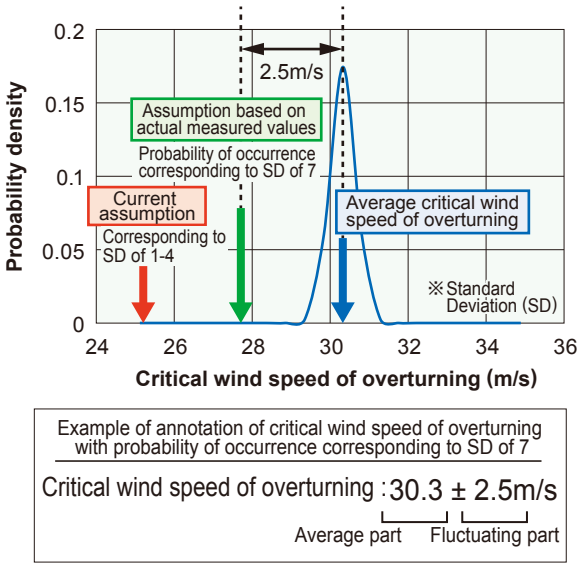


Fig. 3 Example of stochastic interpretation of critical wind speed of overturning (illustrating new annotation method)

12. Method for monitoring state of driving devices using vibration analysis and machine learning

- A method was developed where vibrations are monitored constantly, allowing the system to detect abnormalities through comparison with normal vibrations.
- The method does not require detailed information about the design of equipment or any abnormal vibration data related to failures.
- This method also allows the classification of abnormalities and evaluation of the degree of abnormality based on the abnormal vibration rate per frequency band.

Early detection of driving device abnormalities is required to guarantee the safety and stability of transport. A method for monitoring the state of vehicle driving devices was therefore developed.

An effective way to check the state of traction motors and engines is to monitor vibrations. However, given the complex, changing operating environment of driving equipment, and vibrations generated by actual running of the train, it is difficult to detect abnormalities based simply on the amplitude of the vibration. As such, machine learning was applied to the outcomes of vibrational octave-band analyses, in order to develop a method for detecting abnormalities based on differences with normal vibrations (Fig. 1).

The principal components of vibrational data obtained from octave band analyses were plotted as coordinates. In doing so, any abnormal vibration would produce an isolated plot, making it possible to detect an abnormality based on the distance from the points plotted for normal vibrations.

Then, by separating octave-band analyses results by frequency band and detecting abnormality separately, it is possible to predict the type of abnormality that has been detected (Table 1). Furthermore, by estimating the abnormal vibration rate within a given timeframe, it is possible to evaluate the speed of progression of the abnormality. Trials were conducted with the developed monitoring system mounted on an actual train, which demonstrated that indications of an abnormality were detected 50 days before the auxiliary driving gear malfunctioned (Fig. 2).

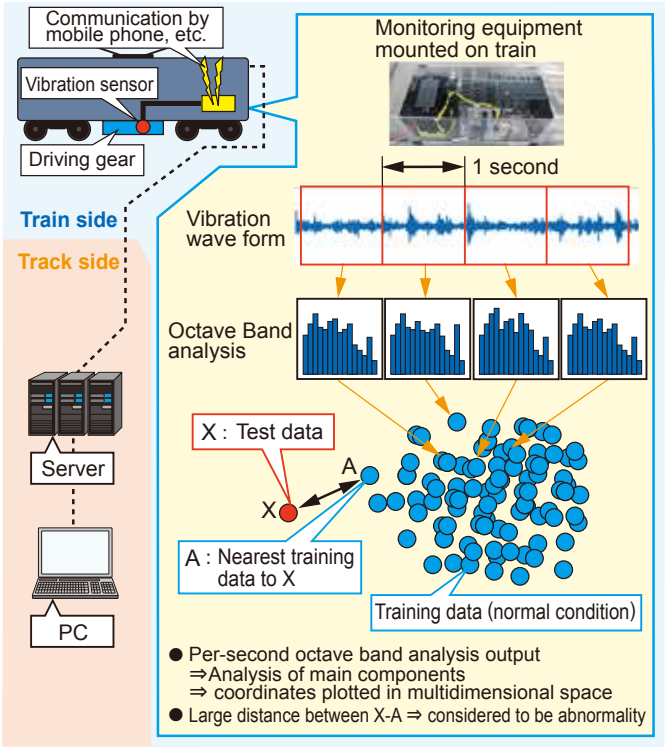


Fig. 1 Conceptual outline of abnormality detection and structure of condition monitoring system

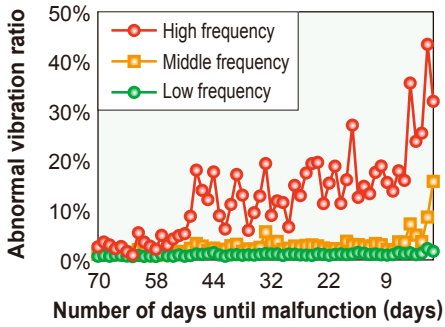


Fig. 2 Abnormal vibration ratio at time of malfunction in auxiliary driving gear due to wear

Classification	Oscillation frequency	Type of abnormality	Remedy (example)
Low frequency	Below 100Hz	・Imbalance ・Misalignment ・Looseness	External visual inspection Dimensional measurement Hammering test
Middle frequency	100Hz ～1kHz	・Looseness ・Wear or collision (Bearing etc.)	Hammering test Lubricant inspection Overhaul inspection
High frequency	More than 1kHz	・Wear or collision (Bearing etc.) ・Flaw or cracking (Bearing etc.)	Lubricant inspection Overhaul inspection

Table 1 Type and frequency of abnormal vibration

13. Wheel flange-wear reducing wheel-tread friction block

- A wheel tread friction block was developed, which reduces wear and friction of the flange by using solid lubricant.
- Tread abrasive material and solid lubricant were combined into a block, which is interchangeable with existing abrasive blocks.
- Line tests with a pendulum express train confirmed that wheel wear could be reduced by approximately 40%.

Wheel flange wear progresses through flange-rail contact as trains run through curves, and a rise in the number of wheel re-profilings leads to increased costs, creating the need to control wheel-flange wear.

However, for noise and the derailment safety margin, a low friction coefficient is desirable. To overcome this problem, flange lubricant is required. Greasing methods do exist, however, they can lead to wheel slipping and transfer of grease to the rail, and a work adjusting lubricant position is required, making these methods sometimes difficult to apply. A new wheel-tread friction block was therefore developed (hereinafter, 'integrated wheel-tread conditioning block'), combining lubrication of the flange and wheel tread adhesion improvement.

The new integrated wheel-tread conditioning block consists of wheel-tread abrasive material which is in contact with the wheel-tread, a built-in solid lubricant component in contact with the wheel flange, and can be installed in existing wheel-tread cleaning devices without modification (Fig.1). The wheel-tread conditioning block is molded as a single piece, and the block as a whole including boundaries between the solid lubricant and the tread abrasive material meet the same strength criteria as existing tread abrasive blocks. Furthermore, the composition of the tread abrasive material in the new block is the same as the tried-and-tested material used in existing tread abrasive blocks.

The new blocks move vertically by the action of the wheel-tread cleaning device, and therefore no adjustment is required for different wheel diameters. In addition, the wear rate of the integrated wheel-tread conditioning block is identical to that of the tread abrasive blocks, so no additional serviceable life management is required.

Introducing the new integrated wheel-tread conditioning block on a pendulum express train, on which existing greasing methods cannot be used, confirmed that wheel-flange wear was approximately 40% lower than without the integrated conditioning block. It was also confirmed that the friction coefficient on the flange was lower (Fig 2).

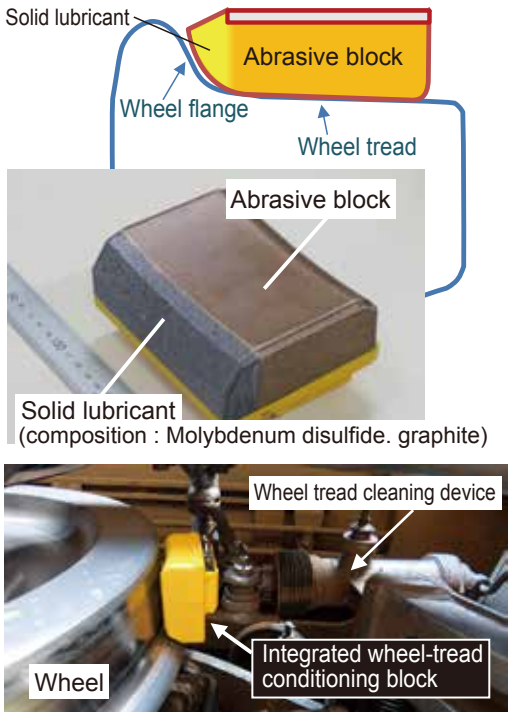


Fig .1 New integrated wheel-tread conditioning block structure and appearance when mounted

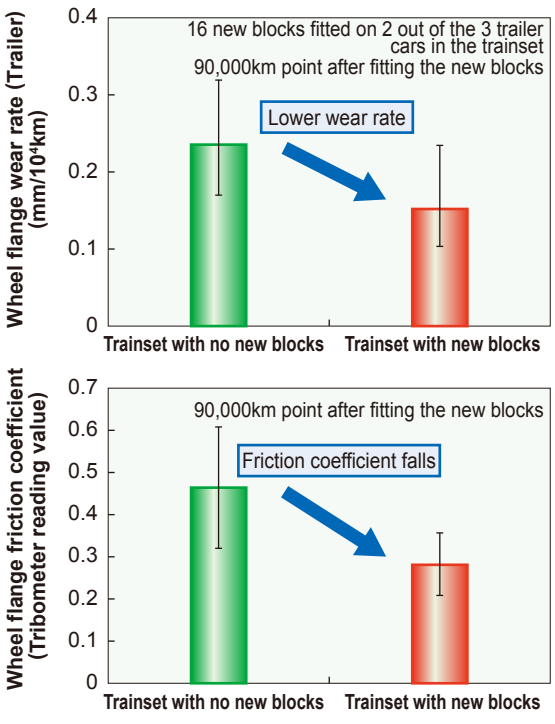


Fig. 2 Reduction of wheel-flange wear / friction

14. High-strength bolted friction joints for existing weathering steel bridges

- A high-strength bolted friction joint connection method with protective rust was developed for the repair or reinforcement of weathering steel bridges.
- Design methods were also proposed corresponding to different rust conditions and different surface properties of the reinforcement/repair members.
- The new method is only 1/3 of the cost of conventional methods.

Weathering steel bridges are a special type of bare-steel bridge where corrosion is prevented by the protective rust that forms on the steel surface (Fig.1). Bridges of this type began being built 40 years ago and today the first signs of fatigue cracking and other damage are beginning to appear, calling for increasingly urgent repair and reinforcement. However, in order to apply repair or reinforcement members, rust has to first be completely removed from the steel surface with large-scale blasting equipment, which is extremely time consuming and expensive.

A method of high-strength bolted friction joints with protective rust was developed for the repair/reinforcement of existing weathering steel bridges. In this method, only the surface grained layer of protective rust is removed with a hand-held electric brush (Fig. 2), and the friction between the contact surface of the inner layer of protective rust and repair/reinforcement member ensures the joint strength (Fig.3). The slip coefficient used for the design of the friction joint strength is determined according to the surface properties of the repair/reinforcement member and the protective rust and depending on the bridge's surrounding environment (Table 1). Furthermore, the surface condition of the protective rust can be classified using a visual inspection index (Table 1). Using the proposed joint method, means that large scale blasting equipment to remove rust in reinforcement/repair work is no longer required, shortening work time and reducing work cost by approximately 2/3.

Fig.1 Weathering steel bridge

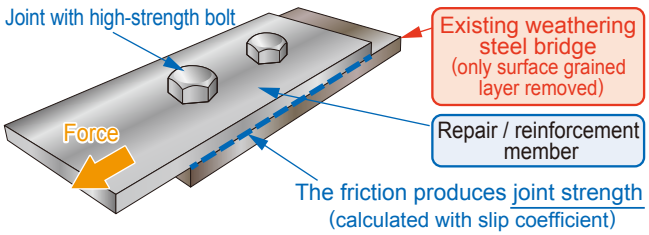


Fig. 3 High-strength bolted friction joints

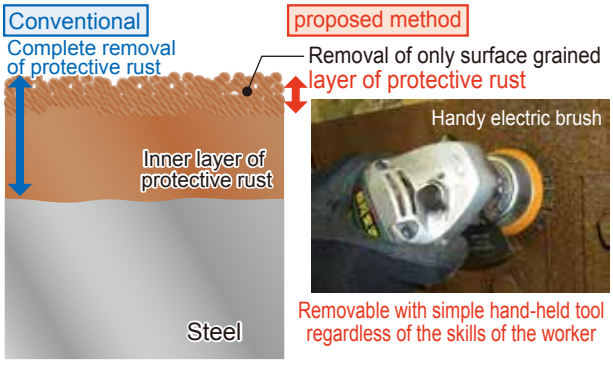


Fig. 2 Removal layer and equipment

Condition of protective rust		Repair/reinforcement member surface properties	
		Blasted steel	Zinc coating
Visual inspection index	5 Good	0.5	0.3
	4		
	3		
	2	0.4 ※Complete rust removal and use of adhesive	
	1 Bad		

Table 1 Slip coefficient

15. Bridge pier stability monitoring method using microtremor data

- A system was developed to monitor the natural frequency of bridge piers using microtremors measured at the top of bridge piers.
- The system allows monitoring of bridge piers even in situations where the influence of ground vibrations is significant.
- Using this method prior measurement of the natural frequency through impact and vibration tests is not necessary.

The stability of bridge piers can be assessed by using the natural frequency of the pier obtained through impact and vibration tests, however, these tests involve creating impacts using weights, which from a practical point of view is not viable for periodic monitoring. As a solution to this problem, a monitoring method was developed using pier microtremor measurements. However, in the case of large ground vibrations, pier vibrations were drowned out by the ground vibrations, so the method could not be applied. Consequently, in contrast with the single measurement location used in this method, another microtremor monitoring method was developed based on two (Fig. 1) microtremor measurement locations on the top on the pier, and then subtracting the estimated ground vibration, to make it possible to monitor the natural frequency of the pier even in conditions where influence of ground vibrations is significant.

The new method (Fig. 2) works as follows: ①two microtremor gauges are placed upstream and downstream on the top of the pier, and two microtremors are measured; ② Ground vibration is estimated using measured values; ③ The estimated ground vibration is then subtracted from the measured values; ④ The values are then converted to a curvilinear regression using a theoretical equation to identify the natural frequency of the bridge pier.

The new method was used to identify the natural frequency of 12 bridge piers, which were compared with the natural frequency obtained through separately conducted impact and vibration tests. The results of this comparison demonstrated that apart from one pier that was in exceptionally good condition, it was possible to identify the natural frequency of each of the 11 other piers even in conditions heavily influence by ground vibrations to within 1 Hz.

Given that this new method does not require prior measurement of the natural frequency through impact and vibration tests, it is much more practical to implement. In addition, since microtremors values are used, it is possible to monitor to the piers even with rising water levels.

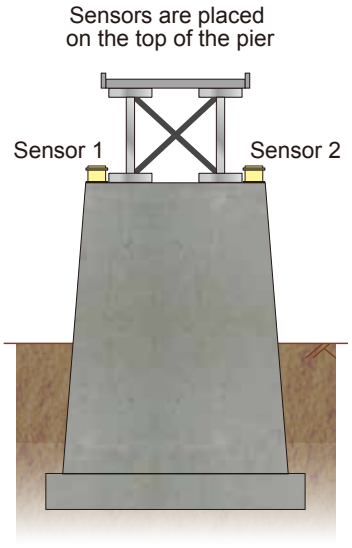


Fig.1 Schematic showing sensor location

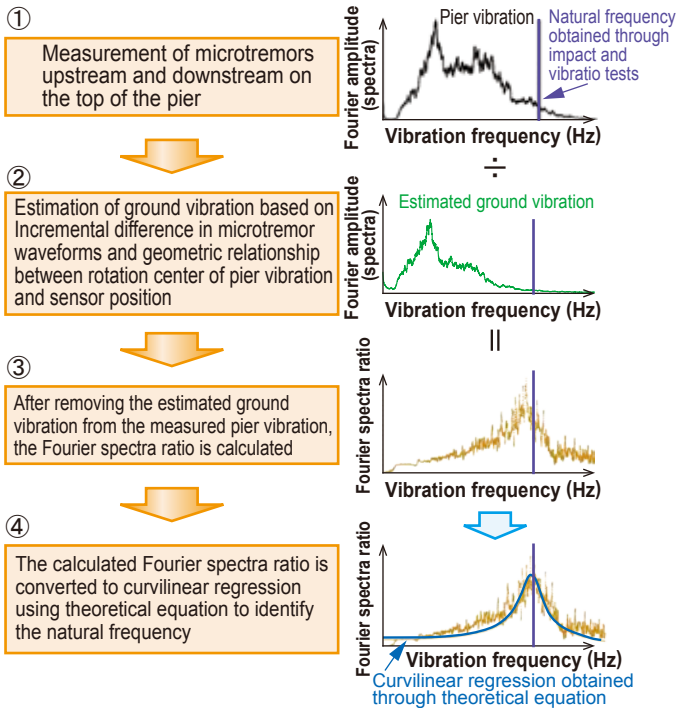


Fig. 2 Process for identifying the natural frequency using the new method

16. Low-cost continuous welded rail track structure suitable for regional railways

- A track structure has been developed that can be introduced at half the actual cost.
- Lateral ballast resistance force is maintained by mixing cement to reinforce existing ballast.
- Tests on a full scale model track confirmed that the track did not buckle with a rail temperature rise of 70 ° C

Rail joints, which are a weakness in tracks on regional railways are a significant problem in terms of maintenance, given their high number, and so a low-cost effective means to reinforce track structures is essential. It is thought that one potential, effective method to solve this problem in particular, would be to develop a low-cost method to introduce continuous welded rails, which would remove rail joints and significantly reduce maintenance costs. However, existing continuous welded rail track structures are designed for trunk lines, and would be difficult to introduce on regional railways given the high implementation cost.

In the proposed track structure, some wooden sleepers are replaced with PC sleepers, while the soil/ballast mix is kept as it is, and joint depressions are sectioned off and welded. In order to maintain the lateral stability obtained through analysis the lateral ballast resistance force of 14.7kN required in certain sleepers is guaranteed by adding cement to the ballast through stabilizing reinforcement (Fig. 1).

The developed continuous welded rail track structure was used to build a full size track model, and rail heating tests were conducted. The results confirmed that after the lateral ballast resistance force reinforcement work was done, no buckling occurred when the temperature of the rail was increased by 70 °C (Fig. 2). In addition, when using RTRI's test line installations, it was confirmed that lateral ballast resistance force track reinforcement work could be carried out for less than 20 000 JPY (approximately 165 Euro or 183 USD) per meter of track.

As a result, the new continuous welded rail track structure can be introduced for less than half the current cost.

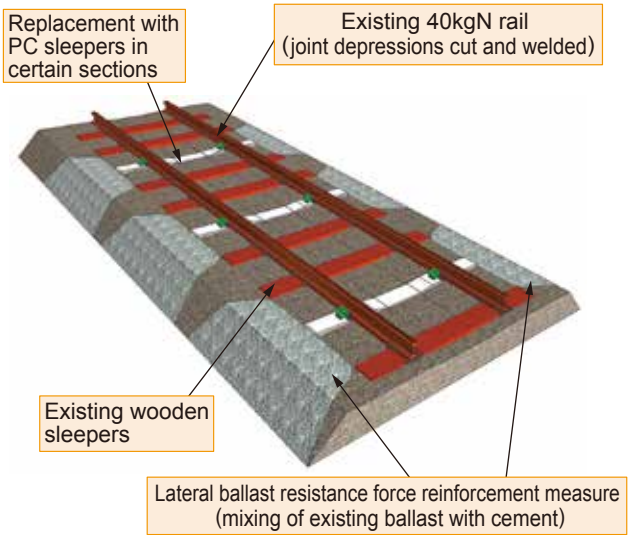


Fig.1 Low-cost continuous welded rail track structure

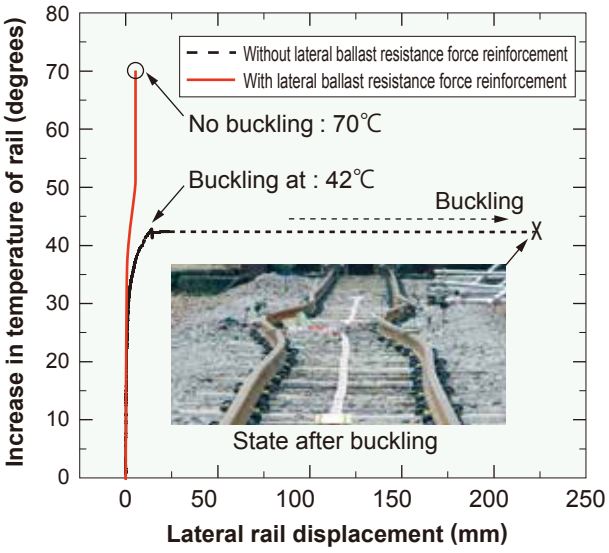


Fig. 2 Result of buckling stability verification experiment using full scale track model

17. Track stiffness inspection method using portable track stiffness measuring device (RFWD)

- A method using a portable RFWD for rapidly inspecting track stiffness was designed.
- The method can be used for checking track stiffness after restoration work and for designing roadbed improvement.

A method was proposed to inspect the state of sleeper support and roadbed stiffness using a portable track stiffness measurement device (RFWD Railway Falling Weight Deflectometer) (Fig. 1 and Fig. 2). The portable RFWD is a device drops a weight onto the rail and, based on the load and the displacement, measures the track spring coefficient. It is therefore used to evaluate track stiffness to assess the need for track repair work or track restoration after work under the roadbed. Up until now, there was no portable machine that could be used along the rails in order to exert a load on the track to inspect track stiffness, however, measuring can be done swiftly with the highly mobile portable RFWD. Using the portable RFWD, measurements on one sleeper can be taken every 11 seconds.

Sleepers lacking the sufficient stiffness (floating sleepers) can be detected (Fig. 3), which makes it possible to check track safety after work has been carried out under the roadbed, or after track restoration work following a disaster, before allowing traffic to resume.

In addition, the track spring coefficient obtained with the portable RFWD can be used to identify locations along the roadbed that require repair, and determine the thickness that needs to be replaced as well.

Several railway operators have commenced pilot tests using the portable RFWD.

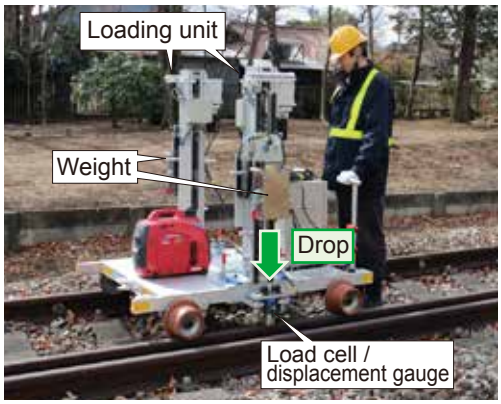


Fig. 1 Portable Railway Falling Weight Deflectometer (RFWD)

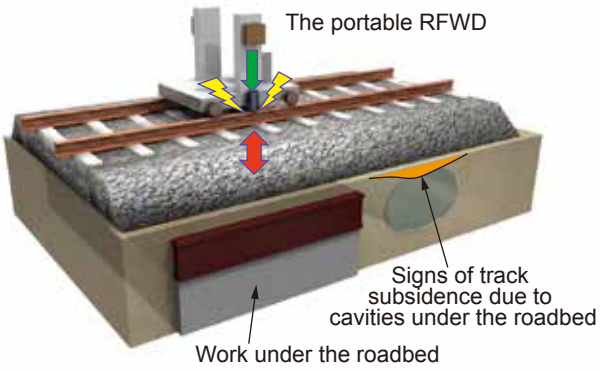


Fig. 2 Inspection of track stiffness using the portable RFWD

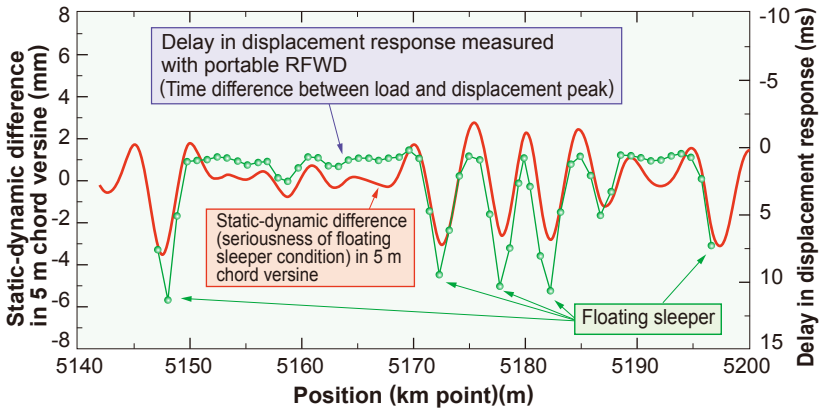


Fig. 3 Example of diagnosis of track stiffness using the portable RFWD

18. Device to determine fouling of structural clearance gauge using on-board 3D laser scanner

- A system has been developed to determine fouling of the structural clearance gauge by any of the numerous facilities that exist beside tracks.
- The device can be mounted on a track geometry inspection car, and in some sections can reduce the need for manual measurements by 90%.
- Confirmation was obtained that the error margin in the lateral direction was less than 200mm.

To guarantee the running safety of railway vehicles, it is essential to determine whether any trackside structures foul the clearance gauge. In the past this was achieved manually or with a specially equipped car for inspecting the structural clearance gauge, however, the problem with this method, is that it is both time and labor intensive, and the initial cost of building such special cars is expensive. Consequently, using a "3D laser scanner" which measures distances to target objects based on beam reflection time, a clearance gauge fouling detection device was developed, which can measure trackside installations continuously (Fig. 1). The device can be mounted on any kind of vehicle, and can inspect structural clearance gauges at up to 80km/h, making it possible to check the structural clearance gauges at a lower cost.

In order to measure the clearance gauge, two pairs of 3D scanners are fitted to the top left and right gable ends of the front of a vehicle. Two more 3D scanners are mounted on each side of the lower part of the front end of the vehicle to measure the track position, to correct vehicle vibration when running. The lateral error in distance measured for larger trackside installations, such as level crossing gates and equipment boxes was within 50 mm, while for thinner items, such as signaling markers, the error margin was within 200mm, confirming that the system satisfied the target accuracy (within 200mm) (Fig. 2). Satisfying the accuracy criterion of 200 mm, signifies that depending on the conditions of the track section, the need for manual measurement could be kept to below 10%.

Given that this device is fitted onto a track geometry inspection car, the structural clearance can be measured according to the schedule of usual track geometry inspections. Consequently, the clearance gauge can be checked now without the need for a specially operated car. In addition, given that the data is collected in 3D configuration (Fig. 3), it is possible to identify which piece of an installation is fouling the gauge, and obtain the cross-sectional shape of the track bed, to determine how good or bad a situation is.

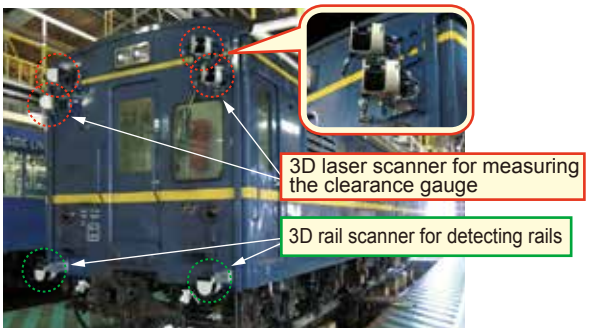


Fig. 1 Example of application of the device for determining fouling of the clearance gauge

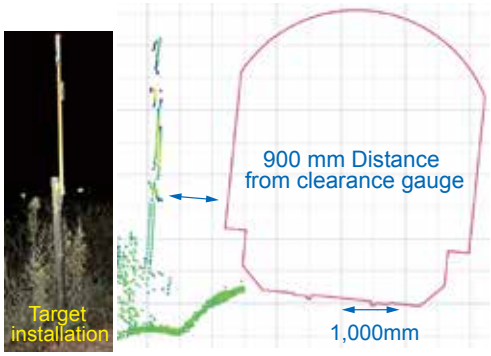


Fig. 2 Measurement of distance from clearance gauge

Fig. 3 3D display of measurement data

19. Method for evaluating characteristics of wheel/rail noise generated in curved track sections

- An on-site evaluation method has been developed to characterize high-frequency noise produced by wheel and rail vibrations above 10 kHz generated on a gently curved track.
- The dominant source of high-frequency noise was identified as being the outside leading wheel of each bogie.
- The method can be used to evaluate the characteristics of wheel/rail noise and serve as a guideline for the development of mitigation measures.

It is common knowledge that squeal noise can occur when a train runs through a sharp curve. However, even on a gently curved section, wheel/rail noise due to wheel and rail vibrations above 10 kHz (referred to as "high-frequency noise") close to the upper limit of the audible frequency range can occur and significantly contributes to wayside noise (Fig. 1). In order to develop measures to reduce this noise, it is necessary to understand its characteristics, such as the contribution to overall noise of each noise source and source localization.

As such, an evaluation method was designed (Fig. 2) combining a transfer function between rail noise and rail vibrations, and source localization technology in the form of a directional microphone. The method was tried on a commercial line which, as shown in Fig. 1, revealed that the dominant source of high-frequency noise was the outside leading wheel of each bogie (in the traveling direction). Furthermore, it is found that the level of the noise depends on train speed (Fig. 3).

The method can be applied to evaluate the characteristics of wheel/rail noise, including high frequency noise, in order to guide the development of mitigation measures.

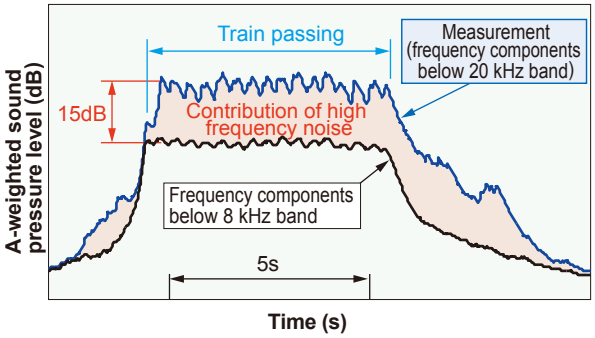


Fig. 1 Time histories of the wayside noise
(At 3.5 m away from the outside rail, curve radius of 2500m, train speed 239 km/h)

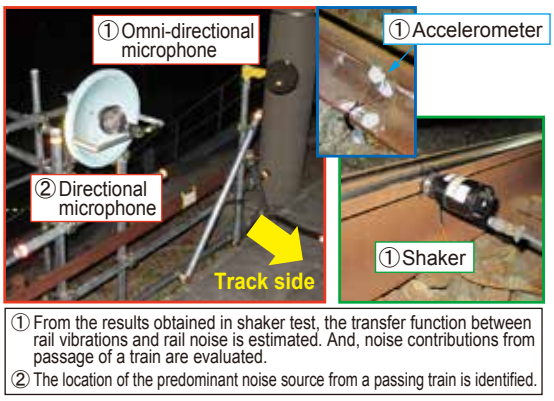


Fig. 2 Outline of evaluation method

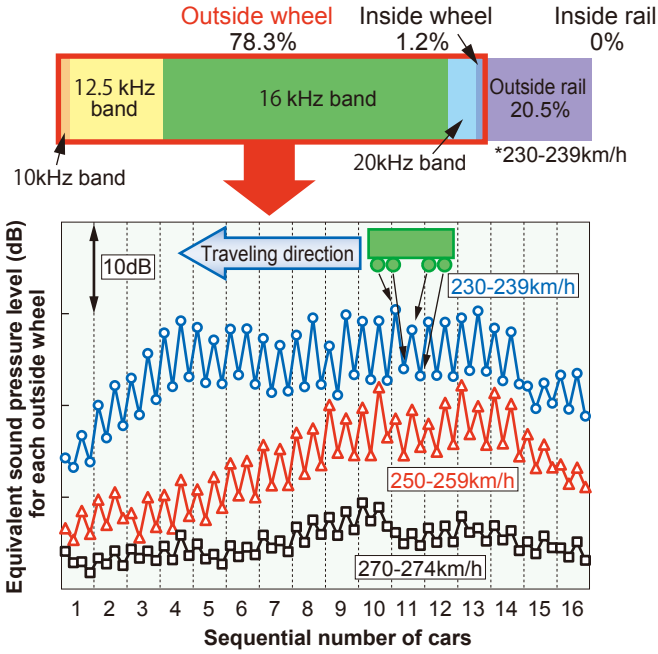


Fig. 3 Contributions of high-frequency noise and location of the dominant noise source in the 16 kHz band

20. Train operation power simulator to evaluate energy-saving strategies

- A simulator has been developed that can be used to calculate the energy consumed during train operation in an actual operating line scale, considering an installing of energy storage systems, under the condition of several lines and many types of rolling stock.
- The simulator is able to evaluate the performance of energy-saving strategies, such as introduction of new types of rolling stock and energy storage systems.
- The energy-saving performance of an energy storage system was estimated and the influence of parameters such as outside temperature, is quantitatively analyzed.

Various energy-saving strategies relating to ground side facilities and onboard systems are being studied, from the view point of reduction of energy consumption, however, in order to assess the performance of these strategies, there is a need for much more accurate energy calculations. A simulator for calculating energy consumed by trains in operation has already been developed, which produces detailed calculations of the current/voltage interaction between multiple substations and multiple trains, and make it possible to reflect changes in acceleration due to variation in voltage to speed profiles. This simulator has now been modified to include a function that generates speed profiles to reproduce average driving operations in commercial traffic. In addition, it can produce practical scale calculations assuming any type of commercial line, that is, any variety of line, rolling stock, and so on. (Fig. 1).

In terms of energy efficiency, parameters such as auxiliary machine power consumption, running resistance and braking operation, etc., significantly influence energy consumption calculation results. To resolve this issue, a new method has now been developed to make use of vehicle related big data collected through on-board information recording systems in order to set parameter values that are as close as possible to reality.

A comparison of actual consumed energy measured during commercial operation on an actual line with estimated values obtained through the new simulator demonstrated that the reproduction of real conditions had been improved from a level of accuracy of about 20-10% to within 5%, confirming a significant step up in performance (Fig. 2). This outcome demonstrated the applicability of the train operation power simulator for evaluating energy-saving strategies.

The simulator was therefore applied to estimate the energy-saving performance of a newly introduced energy storage device. It was found that its energy-saving performance varied between 0.7%~3.3% depending on installation location and outside temperature.

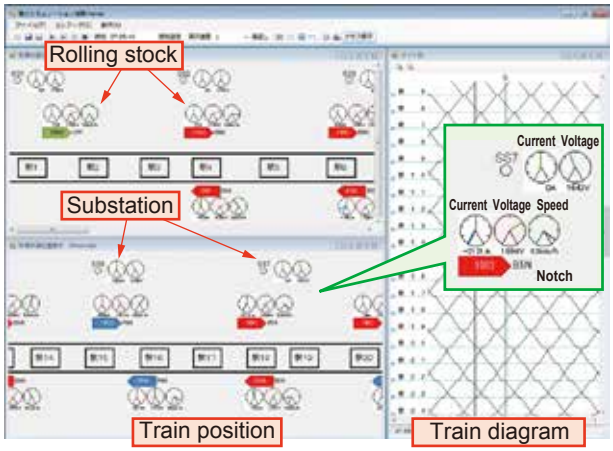


Fig. 1 Example of simulation output display

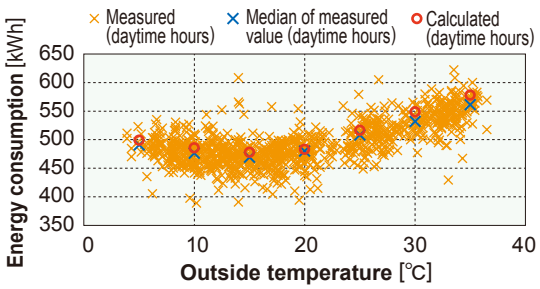


Fig. 2 Result of energy consumption verification

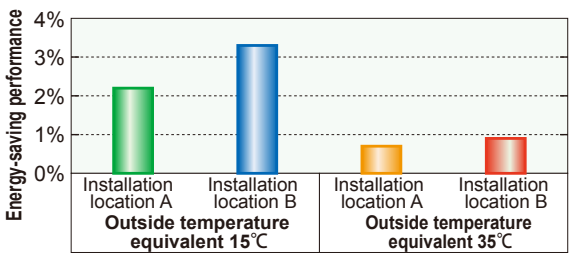


Fig. 3 Estimated effectiveness of energy storage device

IMPROVEMENT OF CONVENIENCE

21. Vertical vibration control method for Shinkansen rolling stock

- A method has been developed to control vertical and rolling vibrations on Shinkansen trains to improve ride comfort.
- The system combines two types of damper and one type of actuator and satisfies the double requirement of improving ride comfort whilst controlling cost.
- Excitation tests simulating actual running confirmed that the maximum ride comfort improvement was over 4dB(LT value).

The ride comfort onboard Shinkansen trains has been significantly improved following the installation on almost all trainsets of lateral vibration control devices. As a result, vertical vibrations can be felt more, and so suitable measures are required in response to this. Vertical vibrations are made up of “rigid vibrations” produced by the car body moving as a whole, and “elastic vibrations” produced by car body deformation: both significantly impact ride comfort. Consequently, a new vibration control method was developed in response to both rigid vibrations and vertical elastic vibrations (Fig. 1).

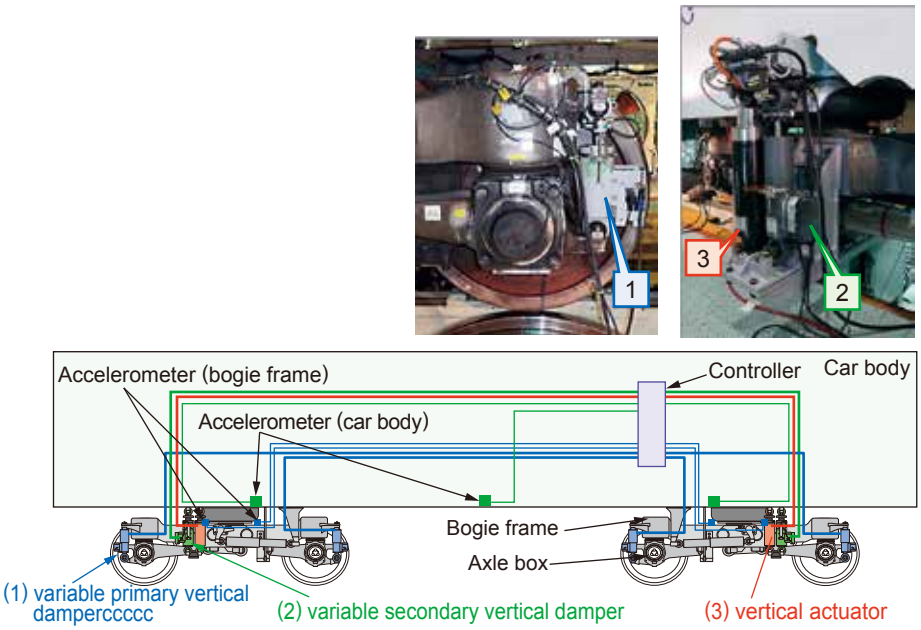


Fig. 1 Structure of vertical vibration control system and example of position when mounted on bogie

The respective vehicle vibrations are controlled by mounting a variable primary vertical damper between the axle box and the bogie frame, and mounting a variable secondary vertical damper between the bogie and the car body. The variable primary vertical damper controls the elastic vibrations of the car body, while the other damper mainly reduces rigid body vibrations. In addition, a newly developed highly responsive vertical actuator is added in between the bogie and the car body to further control and reduce both rigid body and elastic vibrations. This method exploits the positive mutual interaction of these control devices, optimizing vibration reduction / ride comfort improvement. Nevertheless, the three types of control device can be used effectively in any combination or alone, and so can be used flexibly in any configuration depending on the desired ride comfort improvement to be achieved, or cost.

In order to verify the developed method, the devices were mounted on a Shinkansen equivalent vehicle, and excitation tests simulating actual running on the rolling stock test rig were carried out. The results confirmed that the maximum ride comfort improvement that could be achieved was over 4 dB (LT value) (Fig. 2).

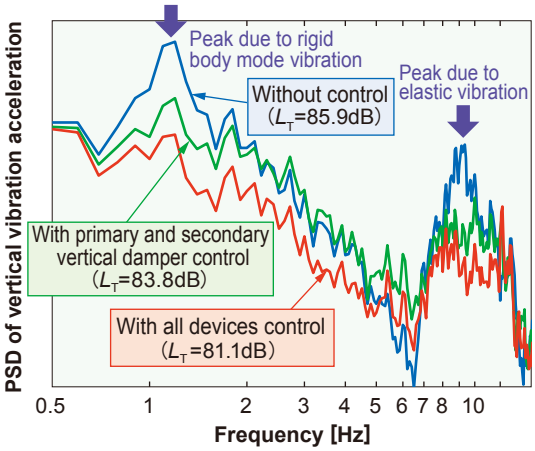


Fig. 2 Example of how vertical vibration is reduced using the new method (results of excitation simulating actual running on rolling stock test rig)

22. Aerodynamic brake design for higher Shinkansen running speeds

- A small light-weight aerodynamic brake assembly has been developed composed of a dual-wing resistance plates.
- A computational fluid dynamics (CFD) analysis of the new assembly mounted properly on the roof of a train set showed that the stopping distance could be reduced by approximately 10% when operating with higher running speeds.

Reducing the stopping distance of Shinkansen trains to improve safety has always been an important topic. In the case of rain or snow in particular, or conditions that reduce wheel/rail adhesion (friction force), a new type of aerodynamic brake has been developed which can complement the braking force in emergencies, such as during an earthquake, etc. The device works by increasing the aerodynamic resistance acting on a running train when necessary, thereby directly reducing the speed of the vehicle with a braking method which does not rely on adhesion. This braking system has the specificity that it generates sufficient aerodynamic resistance when in use, but is folded back into the passenger vehicles at other times, in order to avoid affecting normal operation.

The developed device is composed of one set of two drag plates, which are designed to stay up alone without extra support by virtue of differences between the aerodynamic forces of travelling winds generated when the train is running: the assembly is 65 mm thick, with a mass of 36 kg, and is therefore both lightweight and compact (Fig.1).

A prototype was tested in a wind tunnel with a wind speed of 400 km/h. The maximum resistance force of 2.3 kN (3.5 kN in tunnels) on each set could be obtained within 0.3 seconds after sending the operation command (Fig. 2). The durability of the device was tested by deploying the wings continuously in a speed of 400 km/h over a long period of time (cumulative total of 4 hours of wind blowing), and no problems were observed, while the tests also confirmed that no aerodynamic noise was generated when the wings were stored. Verifications were also made to confirm the operational safety of the device in low and freezing temperatures, and in case of a bird strike, etc.

A computational fluid dynamics (CFD) analysis was carried out by mounting the device on the roof of a 10-car trainset (Fig. 3). After adjusting the location of the device on the roof to achieve maximum drag on the whole trainset, it was demonstrated that the device had the potential of reducing the stopping distance by approximately 10% with a running speed of over 360 km/h.

(a) in storage mode (folded) **(b) Drag mode**

Fig. 1 External view of prototype

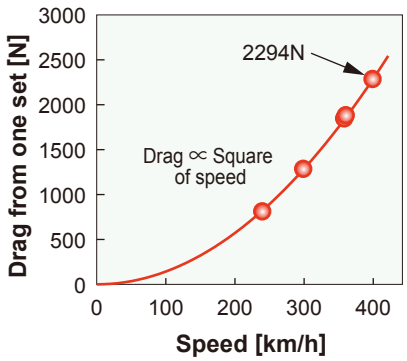


Fig. 2 Drag characteristics (Wind tunnel tests)

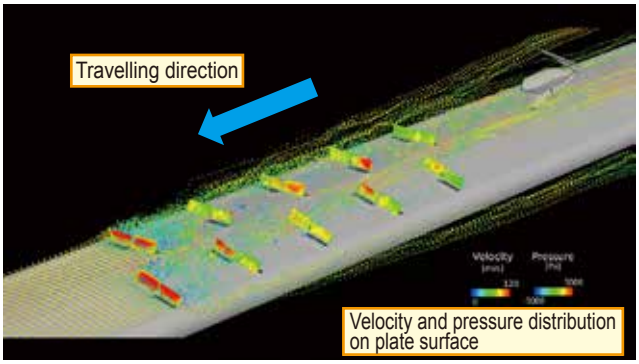


Fig.3 Flow field analysis of train fitted with multiple sets

23. Method for increasing braking force of linear rail brakes

- A method for increasing braking force has been designed for a contactless linear rail brake, capable of controlling increases in rail temperature and which can be operated even with loss of power.
- By combining a new design method which exploits distortion in the magnetic field, and a new control method that employs auxiliary power sources, results found that the new system increased braking power by a factor of 1.9 compared to the previously used system.

In order to reduce the stopping distance of trains operating at high speed, a method for increasing the braking force of a linear rail brake equipped with an alternating current electromagnet (armature) has been developed. The linear rail brake operates in the same way as the eddy current rail brake, where electromagnetic interaction between the armature and the rail generates a braking force. However, with the new device, since the energy needed for it to work is generated by the device itself, it can operate even when power is lost, and because of this feature, is also able to control any rise in rail temperature. In the existing (previous) designs, ring winding electromagnets were used in order to control rail temperature (Fig. 1), however, this meant that there was a limit to the possible increase in braking force, and reduction of weight. Therefore, based on a premise of using fewer devices on a trainset in order to avoid rail overheating, a method was designed that would increase the braking force of each individual device.

The new proposed design has a concentrated winding armature (Fig. 1) and a battery-operated backup auxiliary power source to enable it to function even with loss of power. With the concentrated winding structure, by superimposition of distortion onto the sinusoid magnetic field on the rail generated by the armature, even though the maximum rail temperature increase is greater by a factor of 1.8 at the maximum running speed of the Shinkansen compared to the ring structure, the braking force can be raised by a factor of about 1.5. When the uninterruptible auxiliary power backup was added to the device combined with the energizing system to reinforce the braking force, tests on the prototype armature demonstrated that the braking force could be increased by a factor of 1.9, compared to when the device was only self-powered (Fig. 2).

Based on this method, if the braking function of the trainset is maintained, the number of linear rail braking devices and the additional weight can be reduced by about half. Nevertheless, given that the rail temperature rises by a factor of approximately 1.3, it is being considered for use in emergencies. Estimations suggest that the rail temperature increase would be higher by approximately 1.8 ℃, under the condition that the stopping distance using the new linear rail brakes was be about 10% shorter than using disc brakes alone, and assuming the longest Shinkansen train formation being braked from the maximum running speed.

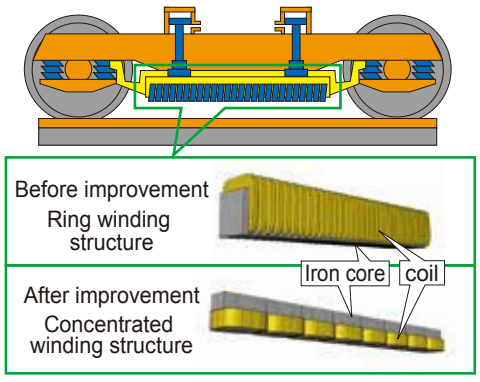


Fig .1 Schematic drawing of armature structure

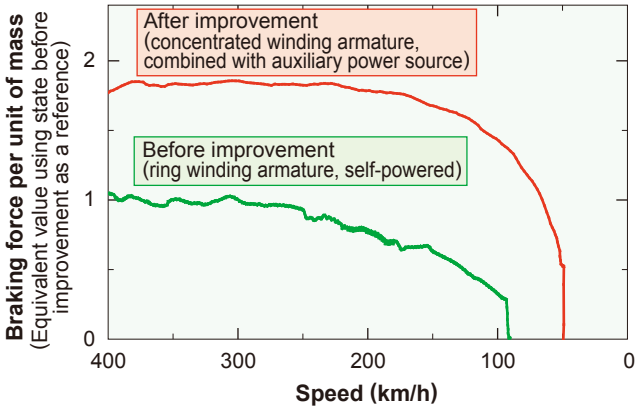


Fig. 2 Comparison of braking force in relation to mass (roller rig test)

24. Development of a CPS contact wire for Shinkansen

- A new CPS contact wire has been developed with equivalent performance of the PHC contact wire used currently on recently opened Shinkansen lines, and which can be produced in small-lots, at a lower cost.
- Tests with the new CPS contact wire on commercial lines showed that the new product posed no problem from a construction point of view, nor in terms of long term use.

Chromium-Zirconium copper alloy (precipitation-hardened copper alloy - PHC®) contact wire with high tensile strength and high conductivity has been introduced on recently opened projected Shinkansen lines since the Tohoku Shinkansen line extension (Hachinohe – ShinAomori section) entered into operation. However, the casting and rolling processes for manufacturing PHC contact wires have to be carried out separately, so even the minimum batch quantity should be large. As a result, this contact wire cannot be adapted to the demand from infrastructure managers that require only small amounts to meet their contact line replacement plan needs.

The newly developed Cobalt-Phosphorus copper alloy (CPS) contact wire offers the equivalent performance of PHC contact wire. This can be cast and rolled successively, resulting in ability to respond to small quantity of order. This feature of production procedure also contribute to reducing cost.

The CPS contact wire was tested not only to determine its mechanical and electrical characteristics, but also its wear and fatigue performance, to verify it possessed the equivalent or better characteristics than PHC contact wires (Figs. 1 and 2). Pilot introduction of the CPS contact wire on both conventional and Shinkansen lines demonstrated that the new product posed no problem in the test use with measuring uplift and strain for 6 months after construction, confirmed that there were no problems in relation to current collection performance including fatigue (Fig. 3). In addition, confirmation was obtained that this contact wire had higher resistance to wear than ordinary contact wire (Table 1).

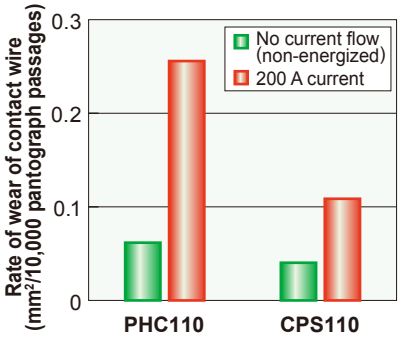


Fig. 1 Wear characteristics (stationary tests)

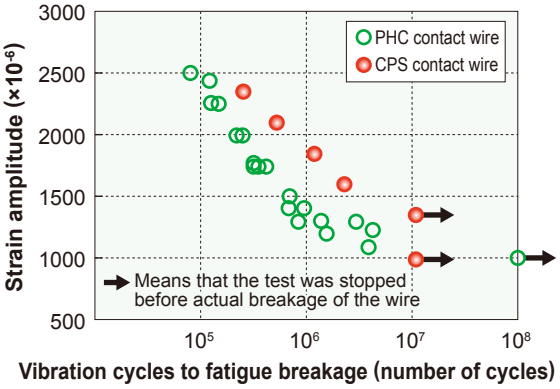


Fig. 2 Fatigue characteristics (stationary tests)

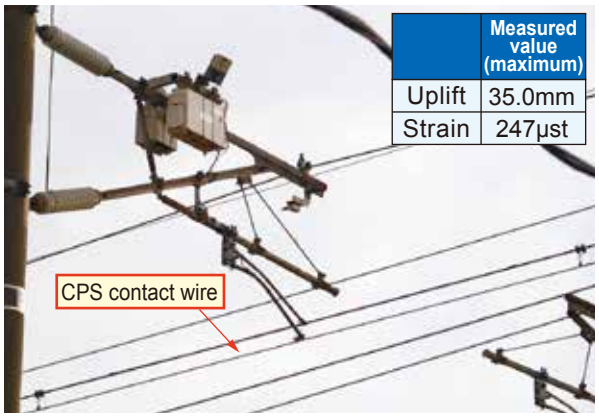


Fig.3 Image of test installation of CPS contact wire on a Shinkansen line and results of dynamic characteristic measurements

Table 1 Results of wear and resistance confirmation tests (from test installation on conventional line)

Type of wire	Annual wear rate (mm/year)
CPS110	0.09
GT-SN110	0.13

25. Yield management method optimizing discount ticket sales quota

- To maximize the revenue of railway undertakings, a method has been developed to optimize the discount ticket sales quota, based on ticket sales data, etc.
- The method supports the decision-making process for setting the quota, making it possible to maximize revenue and facilitate decision-making.

One approach for increasing the revenue of railway undertakings has been to adopt yield management techniques, by setting a quota for discount ticket sales of reserved seats on express trains. However, the difficulty with this method lies in how to quantify its effect on revenue, and how to calculate the optimum sales quota for revenue maximization. Therefore, a method was developed to calculate the optimum sales quota, incorporating demand estimation for various discount tickets and the behavior of passengers purchasing the next-best-option when they are unable to buy their first-choice ticket (Fig.1).

Demand estimation for discount tickets projects ticket sales per train, segment of journey, ticket type and time of booking, based on past sales data according to date. Passenger ticket selection behavior was modelled on the results from a questionnaire, where imaginary passengers were asked what their second choice of ticket would be when their first choice was no longer available: decide to choose an earlier train, a later train, a higher-priced ticket on the same train, or abandon the train journey. This model shows how difference in price between ticket types and time between trains influences passenger choice of ticket. This method was integrated into a system, which can calculate the ticket sales quota and support the decision-process for setting the quota (Fig.2).

This method and system were then applied to ticket sales for a particular express train line as a pilot test by inputting the calculated sales quota into the actual seat reservation system. The result demonstrated that, which may include other effects, the calculated quota increased revenue by approximately 5 to 11% compared to manually-set quotas.

This method supports the decision-making process for setting the discount ticket sales quota, making it possible to maximize revenue and facilitate decision-making.

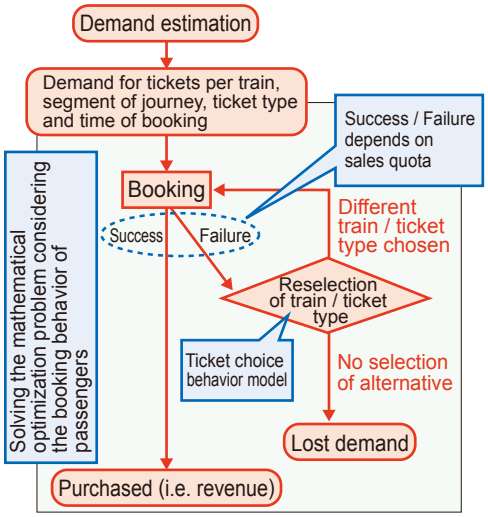


Fig. 1 Developed method for calculating optimal discount ticket sales quota

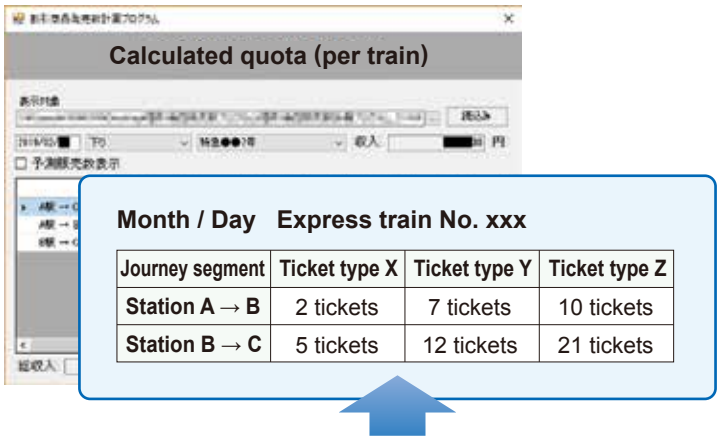


Fig. 2 Example calculation of quota applying developed system

26. Head car collision testing and numerical simulation

- The crash deformation and fracture behavior of a rail carbody structure were determined in a crash test conducted on an actual-size partial railway vehicle.
- Comparison and verification of the simulation output with results from an actual vehicle test confirmed an increase in accuracy of numerical simulation results and a maximum deformation error of approximately 10%.
- Simulation can be used for examining safety improvement measures to better protect passengers and railway staff.

When investigating measures to reduce injuries to passengers and railway staff in the case of a collision accident, tests involving full-scale trainsets are difficult to conduct because of large scale, and so numerical simulation is an effective alternative, but if simulation is used, then accuracy is essential.

Therefore, in order to increase the precision of simulation, a crash test was conducted on a full-scale partial vehicle structure. The test vehicle was cut out from a stainless steel used head car carbody. A special running carriage was built to mount the test vehicle, and a high energy crash test was carried out. The test vehicle collided with a rigid wall at a speed of 54km/h. This speed was established on the basis of a statistical analysis of past serious level crossing accidents in Japan. The results of the test were used to quantitatively investigate the crash behavior of the carbody structure, such as deformation and fracture of the main structural elements (center and side sill, etc.), as well as the crash load/deformation characteristics (Figs. 1 and 2).

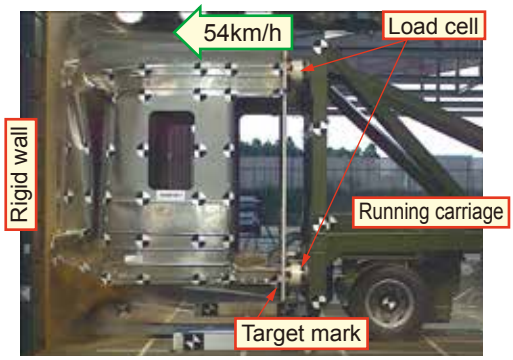


Fig. 1 Deformed shape of an actual-size partial vehicle (high speed camera image)

A comparison of results from an FEM analysis using the same conditions as in the crash test with the actual test results showed that by reflecting various material properties, i.e. strain-rate dependence obtained from tensile tests carried out at various speeds, and spot and arc weld rupture characteristics etc., in the FEM model, it was possible to reproduce the carbody's deformation behavior and load/deformation characteristics with high accuracy. As a result, the maximum load error was approximately 12%, and the maximum deformation error was approximately 10% (Figs. 2 and 3).

This method therefore makes it possible to examine the various types of crash behavior of carbody structures that occur in a collision accident.

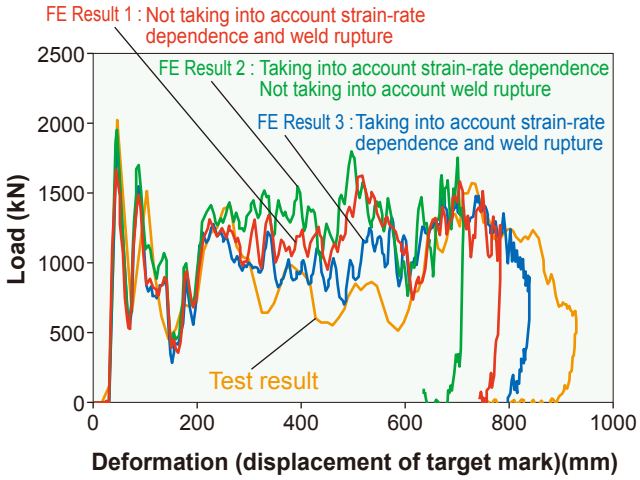


Fig. 2 Comparison of load/deformation characteristic between test and FE results. Taking into account material and weld properties, FE result agrees well with test result.

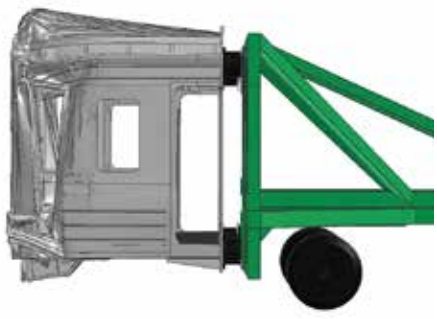


Fig. 3 FE result of deformed shape of test vehicle. FE result agrees well with test result.

27. Snow accretion simulation method for high speed trains

- A new snow accretion simulation method to calculate the shape of snow accretion on high speed trains was developed by combining an airflow simulator with a particle simulator.
- The capacity of the snow accretion simulation method to reproduce the shape of snow accretion a cubic model was confirmed.
- This snow accretion simulation method can be used to find train shapes that reduce snow accretion.

Snow thrown up from passing trains accumulates and gradually collects on train bodies and bogies. When this accumulated snow falls off a running train, it can cause flying ballast, which in turn can cause damage to signaling equipment or train bodies. As a means to explore and develop measures to prevent snow accretion therefore, a snow accretion simulation method has been developed which can reproduce the snow accretion process.

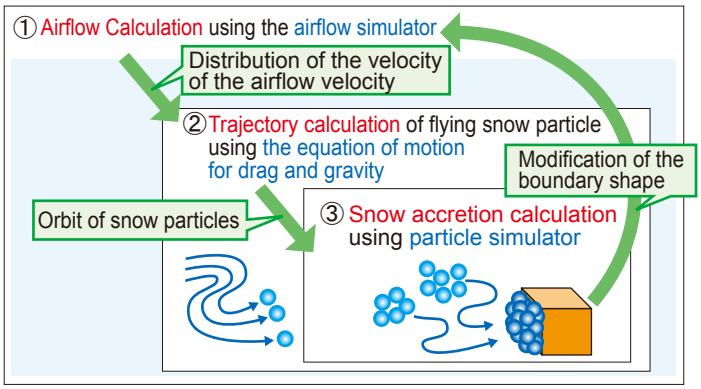


Fig. 1 Outline of the snow accretion simulation method

Fig. 2 Comparison for a cubic model between the snow accretion experiment and simulation

Fig. 3 Snow accretion simulation for a bogie model

The newly developed simulation method combines an airflow simulator with a particle simulator (Fig. 1). The simulation process follows a series of steps: ① The distribution of the velocity of the airflow are calculated around the target object using the airflow simulator. ② The trajectories of the flying snow particles are calculated using the velocity of the airflow. ③ Snow accretion is calculated around the target object using the particle simulator. Given that the target object shape will change as snow accumulates, the shape is updated, and the calculations in steps 1-3 above are repeated to obtain the snow accretion shape on the object. The capacity of the snow accretion simulation method to reproduce a shape similar to that formed during snow accretion experiments was validated using snowfall wind-tunnel experiments (Fig. 2).

Figure 3 shows the results of the snow accretion simulation on a train model. The white dots show the collected snow, while the color of stream lines indicates the magnitude of air flow velocity. This snow accretion simulation method makes it possible to obtain insight into the relationship between airflow and snow accretion, and if applied to the actual train shapes, can be used to find train shapes that reduce snow accretion.

28. Ground-to-train communication system using 90 GHz band millimeter-wave

- It has been demonstrated for the first time in the world that ground to train data transmission at 1.5Gbps using a 90 GHz band millimeter wave is possible at a running speed of 240 km/h.
- This technology can be used to transmit on-board camera images and train state monitoring data to the ground in real time, and to provide on-board passenger services such as internet access and streaming video content, etc.

Train radio systems used today have a narrow bandwidth of several kHz per channel, limiting the data rate that can be transmitted. As such frequency bands with wider bandwidths of several hundred MHz to several GHz were explored, which could be used to transmit large volumes of data. Consequently, attention was focused on the 90 GHz band millimeter-wave which has not been used up until now on the railways, and the component technologies were developed for a ground-to-train communication system.

Based on measurement experiments carried out on viaducts and tunnels, and simulations, it was found that the 90 GHz band millimeter-wave propagation characteristics in the railway environment possessed certain features, such as the lower than free-space . The data relating to weather related attenuation (due to rain fall and/or snow adhesion, etc.) needed for the design of a radio circuit was then collected. A new ground-to-train communication system (Fig. 1) was proposed that combined the 90 GHz band millimeter-wave with Radio over Fiber (RoF) technology, which was then tried out in a demonstration test.

Test results showed that aside from a change in the data transmission rate at one point due to a different antenna angle, track side radio access units (TS-RAUs) connected to the base station were switched at high speed using an optical switch, in accordance with the train running at a speed of about 240 km/h. Consequently, it was verified that data transmission rate was maintained as transmission moved on from one TS-RAU to the next, and that it was possible to continuously transmit data up to a rate of approximately 1.5Gbps (Fig. 2). The results of simulations to estimate radio transmission quality also showed that the new system could probably be used at speeds of over 300 km/h.

These outcomes suggest that the new ground-to-train communication system could allow transmission of up to 750 times more data than is possible with existing systems. Consequently, with the new system it would be possible to stream train condition monitoring data and security camera images to ground in real time.

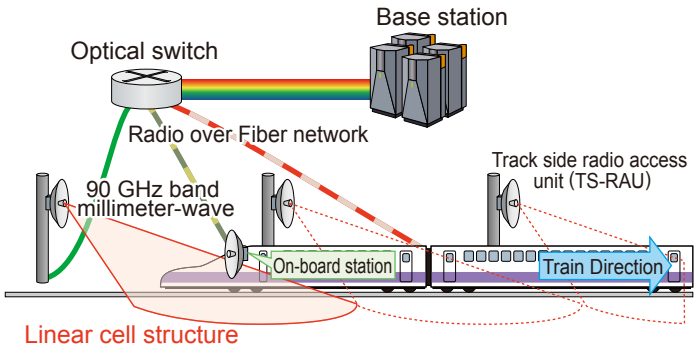


Fig. 1 Proposed configuration of the ground-to-train communication system combining 90 GHz band millimeter wave and radio over fiber (RoF)

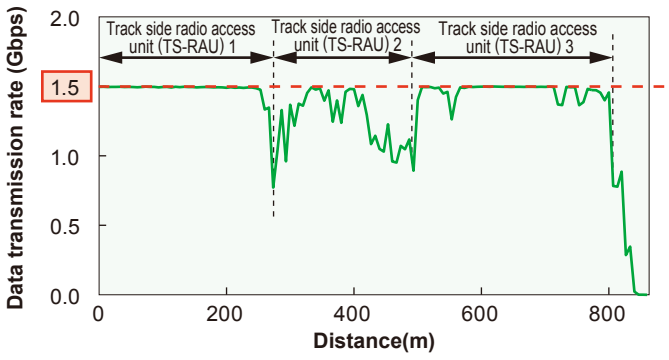


Fig. 2 Results of the demonstration test

29. Mechanisms underlying slope collapse due to rain or during an earthquake resulting from changes in water content of volcanic soil

- A constitutive model has been proposed to express deformation and strength characteristics of volcanic ash soil in case of change in water content.
- Based on simulations of changes in water content and strength of volcanic ash soil due to rain and during earthquakes, mechanisms underlying tephra-covered slope collapse were clarified.

Recent years have seen significant damage to tephra-covered slopes due to rain and earthquakes. Volcanic ash soil covers approximately 40% of Japan's land surface, and is different from ordinary soil and loosely deposited. Therefore, it has a water content which varies easily in case of rainfall and during earthquakes. Consequently, changes in deformation and strength characteristics of volcanic soil due to variations in its water content need to be clarified in order to examine the mechanisms involved in collapse of slopes constituted of this type of soil (Fig.1).

Mechanical tests were carried out on various types of unsaturated volcanic ash soil to examine changes in water content while subject to a load, in order to understand the strength and deformation characteristics of volcanic soil. Through these experiments it was found that an increase in water content reduced strength, and that even if water content was low, repeated loading increased pore water pressure and could lead to liquefaction (Fig. 2). A model was then proposed to express the variation in strength and deformation characteristics depending on changes in water content of the soil. This was then incorporated into a coupled permeation – deformation computational analysis considering the three phase conditions of soil/water/air. Then, after carrying out a numerical analysis of an actual slope collapse it was found that an increase in water content within the volcanic ash soil layer caused slope stability to decrease, leading to deformation (Fig. 3).

By applying the mechanical tests which can take into account changes in water content together with the numerical analysis method, it was possible to clarify the mechanisms involved in volcanic ash soil slope collapse in case of rainfall and during earthquakes.

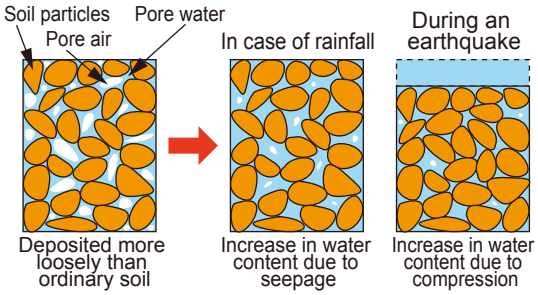


Fig. 1 Characteristics of volcanic ash soil

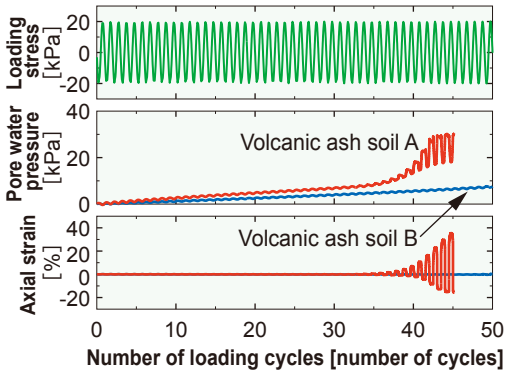


Fig. 2 Model of behavior of volcanic ash soil during cyclic loading

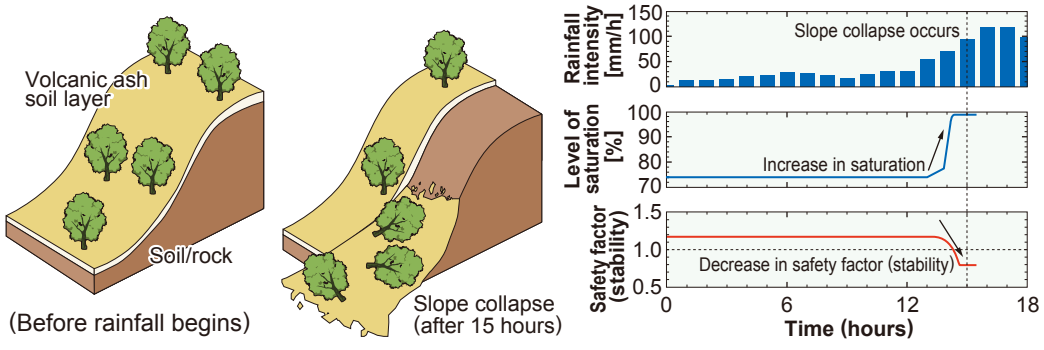


Fig. 3 Collapse mechanism of tephra-covered slope

30. Factors influencing concrete deterioration due to expansion

- We found that alkali-silica reaction (ASR) contributes to delayed ettringite formation (DEF) progression, which is one of the factors leading to expansion deterioration in concrete.
- This has revealed the need of maintenance management that takes into account the compound causes of deterioration of concrete structures in ordinary environments.

Delayed ettringite formation (DEF) is one of the causes of concrete deterioration. DEF occurs when high temperature environments decompose a cement hydrate called ettringite produced inside concrete. This then regenerates over time, leading to expansion cracks in concrete. Previous studies have reported cases of suspected compound deterioration of alkalis-silica reaction and DEF in concrete railway structures (Fig. 1). However, research conducted on conditions that accelerate DEF has failed to clarify the probability of DEF generation in concrete structures in ordinary environments or demonstrate whether ASR had any influence on the occurrence of DEF.

Consequently, we investigated this influence, and found that decreasing pH in concrete when ASR occurred, created an environment where expansion of concrete due to DEF occurred more easily (Fig. 2). Similarly, we found that ASR deterioration encouraged DEF expansion even in ordinary environments with a low presence of sulfate and water, causing cracking similar to that of actual concrete structures. These results indicated that similar cracks could appear due to complex deterioration in concrete structures even in ordinary environments (Fig. 3). DEF occurs in concrete structures with a history of early exposure to high temperatures during construction, which could be accelerated by the decrease in the pH of the concrete. Thus, we suggested that the influence of DEF should be taken into account during repairs.

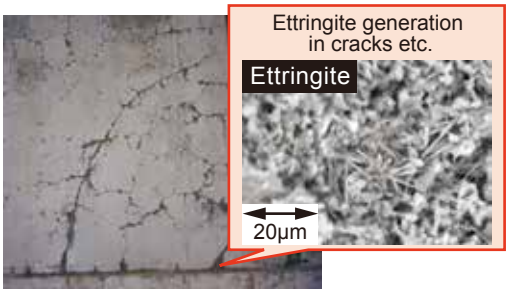
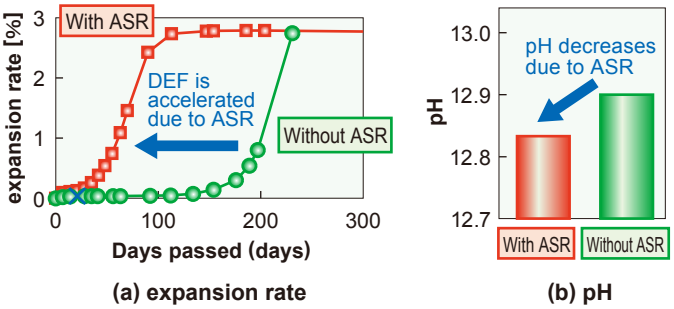
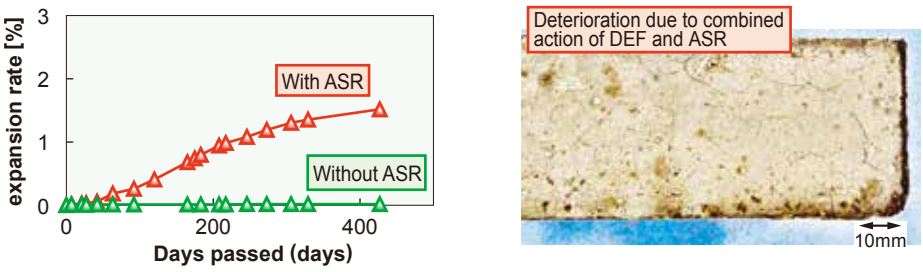


Fig. 1 Examples of concrete deterioration due to combined action of DEF and ASR



(a) expansion rate (b) pH

Fig. 2 Effect of ASR on DEF expansion (under unfavourable conditions)



(a) expansion rate (b) Crack state

Fig. 3 Effect of ASR on DEF expansion (under ordinary conditions)

News Release

1. WCRR 2019 Headquarters Launched

The Railway Technical Research Institute (RTRI) will co-host, with international organizing committee members, the 12th World Congress on Railway Research (WCRR 2019) which is scheduled from October 28th to November 1st in 2019. Since last year, the preliminary office for WCRR 2019 has been working, and on April 1 this year, the WCRR 2019 Headquarters were launched at RTRI, staffed with new members. At its opening ceremony, RTRI's President Kumagai and General Manager Uzuka who leads the Headquarters' team made following statements.

President Kumagai's greetings

Here the WCRR 2019 Headquarters were launched. The countdown has already started for the congress which is 18 months away. Since WCRR'99 was held in Tokyo in 1999, the role of WCRR congresses have gradually changed while Japanese railway systems and technologies have made great strides. The coming WCRR 2019 will be able to provide participants from abroad with a significant opportunity to see the Japanese railway systems and to share views and information. I hope that the team of the headquarters will think hard and create an inspiring and productive congress. The entire staff of RTRI will back up the team.

General Manager Uzuka's statement

WCRR 2019 Headquarters made a start with seven members. Considering the advancement of Japanese railway systems into the global market, It is highly important to have an occasion where railway engineers and managers and executives of railway operators from around the world gather together. The headquarters team will dedicate efforts so that the participants will be able to have wonderful "customer experience."

General Manager Uzuka (center left) President Kumagai (center right)

WCRR congresses have been held since 1994 and world's railway engineers and people in railway management have participated together. WCRR has missions to promote railway technical research and development, to enhance the values and benefits of railways and to offer opportunities for international cooperation. The congresses have been organized by the WCRR Organizing Committee consisting of UIC, SNCF, DB, Trenitalia, RSSB and TTCI which lead world's railway research.

		Place	Main host
1	WCRR '94	Paris	SNCF
2	WCRR '96	Colorado Springs	TTCI
3	WCRR '97	Florence	Trenitalia
4	WCRR '99	Tokyo	RTRI
5	WCRR 2001	Cologne	DB
6	WCRR 2003	Edinburgh	RSSB
7	WCRR 2006	Montreal	TTCI
8	WCRR 2008	Seoul	KRRI
9	WCRR 2011	Lille	SNCF
10	WCRR 2013	Sidney	ARA
11	WCRR 2016	Milan	Trenitalia
12	WCRR 2019	Tokyo	RTRI

WCRR 2019 will be a good opportunity to showcase Japanese railway technologies in addition to provide the place for information sharing. WCRR 2019 is the second one held in Tokyo, following WCRR '99.

With the main theme of WCRR 2019, "Railway research to enhance the customer experience," participants from railway operators, industries and research institutes are expected to deliver presentations which contribute to improving the experience of railway customers from their own standpoints.

Call for Papers and the brochure for sponsors and exhibitors are scheduled to be released in the end of April this year. The abstracts for presentation will be called in May and we would like to ask for your participation as sponsors and exhibitors.

http://wcrr2019.org/

2. ICT Innovation Project Launched

The Railway Technical Research Institute (RTRI) started the ICT Innovation Project.

1. Purpose

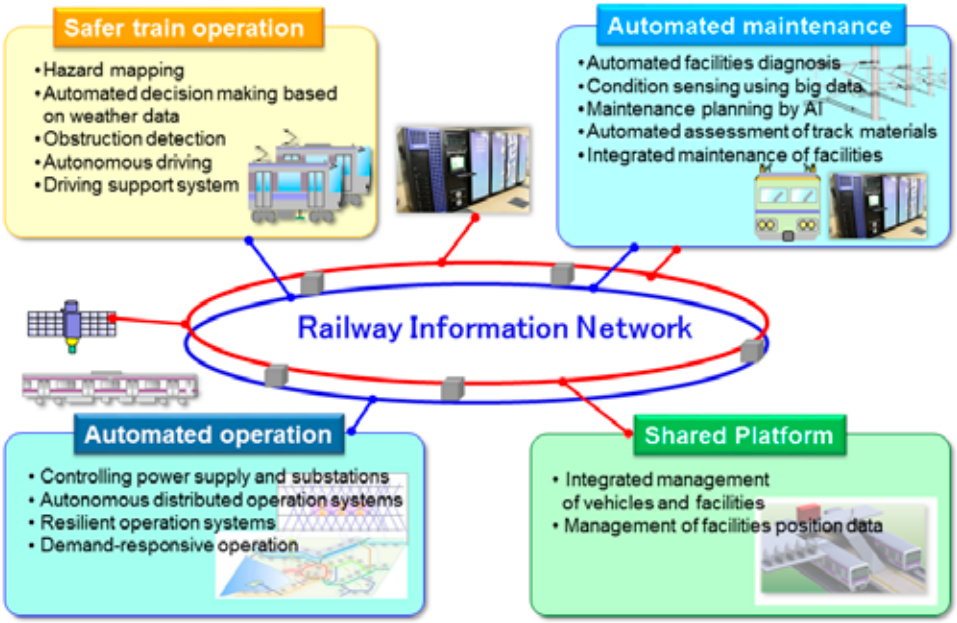
According to the report by the ICT Promotion Team set up in June 2017, the ICT Innovation Project aims to implement R&D to provide solutions for railway technical issues and to promote innovation by using ICT (Information and Communications Technology).

2. Responsibilities

ICT Innovation Project will fulfill the following responsibilities.

- To set the direction of the R&D to apply ICT to railway systems
- To choose research topics regarding ICT and prepare the roadmaps
- To examine how to implement the R&D on ICT and how to use the research resource

Targeted topics for ICT application are shown in the figure below.below.



Safer train operation

- Autonomous driving using the object-detection technology
- ICT-supported operation control and autonomous driving which stops trains, reduce the speeds, or move trains to safer spots according to the situations

Automated operation

- Energy-saving operation, flexible operation meeting delays and changing demand, autonomous driving

Automated maintenance

- Diagnosis of facilities based condition-monitoring data, analysis of big data, machine learning, simulation, condition prediction combined with cross-sectoral database, automatic maintenance planning

Shared platform

- Safe and flexible operation, automated operation, the information network for automated maintenance, operation management system integrating facilities conditions and train positions

3. Organization

ICT Innovation Project consists of researchers in the broad-ranging technical fields under Project Manager Kumagai, President of RTRI.

Norimichi Kumagai	Project Manager President
Kimitoshi Ashiya	Deputy Manager Executive Director
Shigeto Hiraguri	Working Leader Deputy Director Research and Development Promotion Division
Atsushi Furukawa	Director Research and Development Promotion Division
Yuichiro Takata	Chief Manager Research and Development Promotion Division
Minoru Kondo	Senior Researcher Drive Systems, Vehicle Control Technology Division
Masayuki Koda	Director Structures Technology Division
Mitsuru Ikeda	Director Power Supply Technology Division
Katsumi Muramoto	Director Track Technology Division
Yosuke Tsubokawa	Senior Researcher Track Geometry and Maintenance
Kunihiro Kawasaki	Director Signalling and Transport Information Technology Division
Masato Ukai	Principal Researcher Signalling and Transport Information Technology Division
Hideki Arai	General Manager Signalling Systems Signalling and Transport Information Technology Division
Kazuki Nakamura	General Manager Telecommunications and Networking Signalling and Transport Information Technology Division
Nozomi Nagamine	Senior Researcher Image Analysis and IT Signalling and Transport Information Technology Division
Masamichi Sogabe	Director Railway Dynamics Division
Chizuru Nakagawa	Senior Researcher Ergonomics Human Science Division

4. Overview of the 1st meeting

The ICT Innovation Project had its first meeting on April, 20. At the meeting, after President Kumagai's remark, the direction of using ITC was discussed and the following was proposed:

A road map of the automated train operation and maintenance needs to be prepares.

How to share basic technologies including machine learning and big data analysis should be discussed.

5. Schedule

The goals and effects of using ITC will be discussed and a research map showing the topics, processes and time schedule of the research on how to use ICT.

President Kumagai's remark

Following the report by the ICT Promotion Team, several research projects have already been started this year, and in December last year, Image Analysis and IT Laboratory was set up. I hope that this ICT Innovation Project will show the direction and schedule of research and development and the picture of future railways, and actively communicate information. We would like to have steady, open and lively discussions.

The 1st meeting

3. RTRI Updates Its Super Computer

The Railway Technical Research Institute (RTRI) introduced a new supercomputer and its opening ceremony was held on May 18. With this machine, we will be able to run simulation programs to analyze railway technical issues with more reality and to provide more practical and direct solutions. It will also be used for the research to apply information and communications technology to railway systems.

The new supercomputer, Cray XC50, was chosen based on its processing capacity, cost, compatibility with currently-used applications and versatility. It has five times faster processing speed than the replaced machine. (Table 1)

On this machine, the massive parallel numerical simulator and ISV application will be run and a variety of phenomena regarding railways will be analyzed.

President Kumagai of RTRI and Mr. Mamoru Nakano, President of Cray Japan Inc.
at the opening ceremony

President Kumagai's greetings at the opening ceremony

After the research over 18 months, our new super-computer started operation Today. Thanks to the efforts of Cray Japan Inc., we have introduced an extremely high-performance machine. In addition to this advanced tool, we will have to use our wisdom and intellect so that we will continue research to enhance safety and technology of railways and fulfill our mission to make railway systems more attractive. I believe our researchers will produce significant outcomes by fully utilizing this machine.

Table 1 Comparison of the performance of old and new supercomputers

Machine	New	Old (two machines)	
	XC50	XC30	CS300
Type	Large-scale parallel computer Multi-purpose computer	Large-scale parallel computer	Multi-purpose computer
Number of processors (Number of cores)	524 (9,432)	448 (5,376)	16 (112)
Memory	49 TB	14.3 TB	343 GB
Storage	720 TB	220 TB	11.2 TB
OS	CLE 6.0 (Cray Linux Environment)	CLE 5.0 (Cray Linux Environment)	Linux (RedHat EL6.3)
Theoretical computation performance	815 TFlops	103.2 TFlops	11.5 TFlops
		Total 114.7 TFlops	
Practical performance ratio	5	1	

President Kumagai is booting the CRAY XC50

4. Proving Test of Superconducting Feeder Cable System Conducted on JR East Chuo Line

The Railway Technical Research Institute (RTRI) has been developing a superconducting feeder cable system. This year, under the support by JR East, the team has connected the system to the power-feeding system of the Chuo Line and conducted power-feeding tests for the first time at home and abroad. In the testing, it was proved that this system is effective in maintaining stable voltage by reducing electrical resistance.

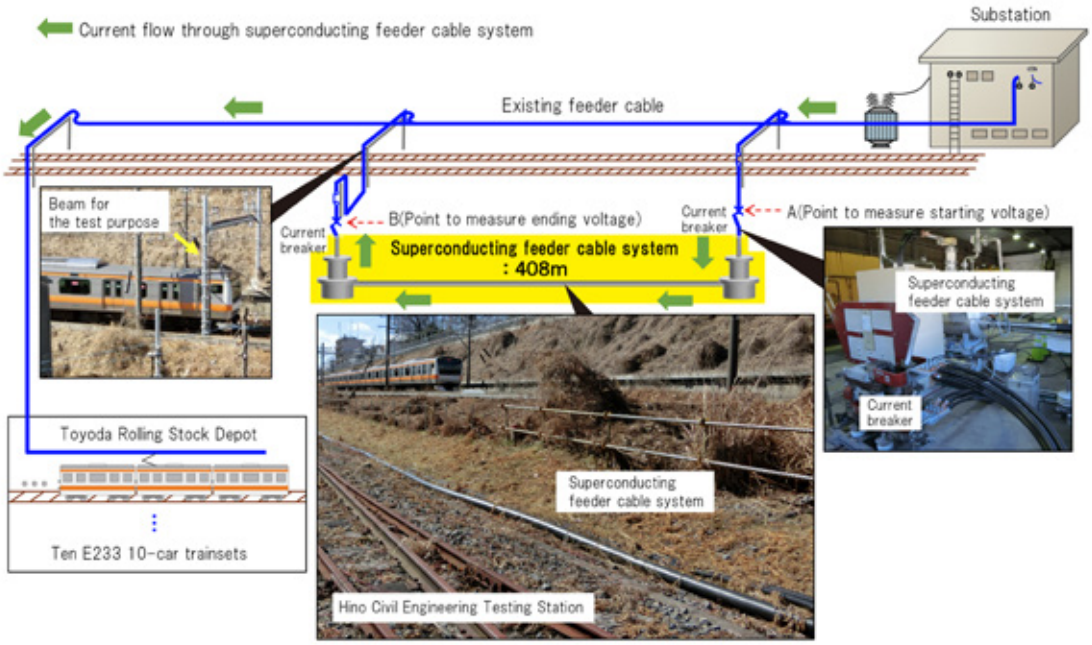


Figure 1: Power feeding system for the tests and current flow

【Test results】

408-meter-long superconducting feeder cable system was installed at RTRI's Hino Civil Engineering Testing Station and its superconducting state was maintained by a cryocooler using liquid nitrogen as a coolant. Then the system was connected to feeder cable running from Hino substation to Toyoda on Chuo Line and test transmission to Toyoda Rolling Stock Depot was conducted after the last train service. (Figure 1) In this test, air conditioning equipment and lighting fixture of ten E233 10-car trainsets were turned on. While the testing, the measured voltage showed almost same level of values at both ends of the system and it was confirmed for the first time at home and abroad that the voltage drop value measured on existing feeder cable, 9.41v, was reduced to below 0.02 v. (Figure 2)

It means that the power loss in this 408-meter range was reduced about 7kW through the transmission by the superconducting feeder cable system.

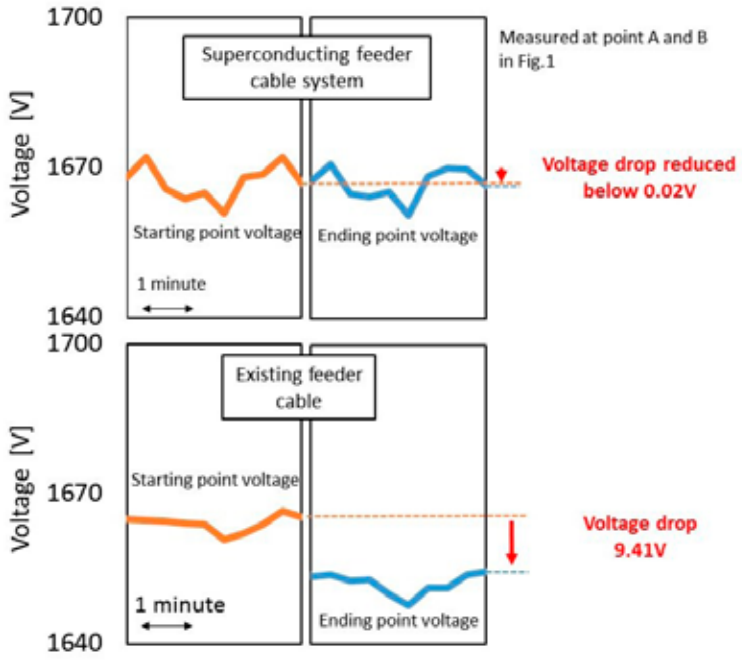


Figure 2: Reduced voltage drop by superconducting feeder cable system

【The effect of the superconducting feeder cable system】

While electricity is transmitted from substations to trains, energy loss is caused by electrical resistance of feeder cable. Therefore, it is required that substations be placed with a close interval in order to prevent voltage drop when trains receive power. When a train applies brake, the kinetic energy of revolving motors is converted to electricity, sent back to feeder cable, and reused to power other trains running nearby. If the train is running in a distant position, however, the regenerated energy cannot be used effectively because resistance of feeder cable increases in proportion to distance.

Since this superconducting feeder cable system can reduce the resistance to almost nothing, it is expected to be an effective solution to the issue of energy loss. Going forward, we will confirm the effects through running tests on commercial tracks, using test trains. At the same time, in order to attain commercially applicable performance level, we will extend the length of the currently 408-meter feeder cable system and improve the cooling performance of the cryocooler in order to keep stable superconductivity in the cable.

◇ Part of this project has been supported by the program to promote creation of Innovation and the program to create future society by the Japan Science and Technology Agency and the subsidy for railway technical development by the Ministry of Land, Infrastructure, Transport and Tourism.

5. A Team Launched to Develop Advanced level-Crossing Obstruction Detection System

The Railway Technical Research Institute (RTRI) set up Team for Advanced Obstruction Detection System on September 1 in order to promote utilization of the advanced obstruction detection system in level-crossing of commercial-service lines.

1. Purpose

RTRI is currently developing a level-crossing obstruction detection system using far-infrared image processing technology. We will further improve its image processing technique and make the safety performance as perfect as possible in order to develop a commercially-applicable system. This is why the new team was launched and it is part of RTRI's commitment to railway innovation using information and communication technology.

2. Responsibilities

The team will fulfill the following responsibilities. It is a temporary team with a one-year term limit.

- To share the information on the development of other systems.
- To compare performance of similar technologies
- To identify issues to be cleared before completing commercial products (improving image-processing technique, confirming safety performance)
- To gather demands and requirements from railway operators
- To set development targets

3. Overview of the kickoff meeting

The team had its first meeting on September 3. At the meeting, after the remarks by President Kumagai and the team leader, Executive Vice President Watanabe, their expected activities and policy were discussed.

【President Kumagai's remark】

In April, we started ICT Innovation Project and have been reviewing broad-ranging technical fields from an interdisciplinary perspective. It is important to finish each technical component in order to produce substantial output for one research topic. As the first topic of ICT Innovation Project, we will improve the detection system for level-crossing obstruction that we have already been developing. This team will implement research and development with a high goal of applying the advanced level-crossing obstruction detection system to commercial railway lines. Through this project, all of us will make best efforts to contribute to the safety of railway transportation.

【Team leader, Executive Vice President Watanabe's remark】

RTRI has so far developed several types of level-crossing obstruction detection devices including ultrasonic-wave type and stereo-image type. However, none of them have been used widely due to various reasons. Now, this team was set up and we will work toward the purpose of completing commercially-applicable level-crossing obstruction detection system using far-infrared image processing technology. We will identify the characteristics and the performance limit of the system and introduce it to the places where it will fit in. Since the research cost and schedule are also important, the team members will share such information through the project work. As the term of this team is limited to one year, we would like to implement well-focused tasks effectively.

【Organization of the team】

Leader

Executive Vice President

Assistant Leader

Deputy Director, Research and Development Promotion Division

Director, Signalling and Transport Information Technology Division

Senior Chief Researcher, Train Control Systems Signalling and Transport Information Technology Division

Member

Director, Assistant Senior Researcher, Researcher Signalling Systems

Signalling and Transport Information Technology Division

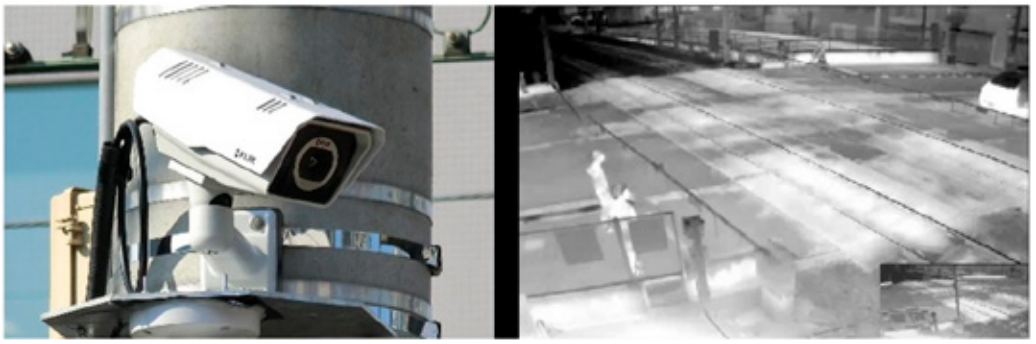
Director, Senior Researcher, Researcher Image Analysis and IT

Signalling and Transport Information Technology Division

Kickoff meeting

*** Level-crossing obstruction detection system using far-infrared image processing technology**

This device detects obstructions in level crossing by analyzing thermal images taken by far-infrared camera. This is less susceptible to the impacts of weather conditions and sunbeam and does not require lighting. We are using mechanical learning technology to develop a system that is capable to detect any shape of objects with a size of 20×100cm.



Far-infrared camera | Image of level crossing

6. RTRI Develops a Low-Cost Ballast Track Maintenance Method

The Railway Technical Research Institute (RTRI) developed “Ballast Stabilization Method Using Biodegradable Polymer” as a low-cost ballast maintenance measure to prevent aged ballasted tracks from subsiding.

【Main features】

- Biodegradable polymer and accelerator are poured into fine-grained ballast to reinforce the ballast and prevent the track from subsiding and to reduce maintenance cost.

- The repairing material is widely used as a ground stabilizing material. As it does not cement the ballast too hard, ordinary tamping is still effective to maintain the ballast.

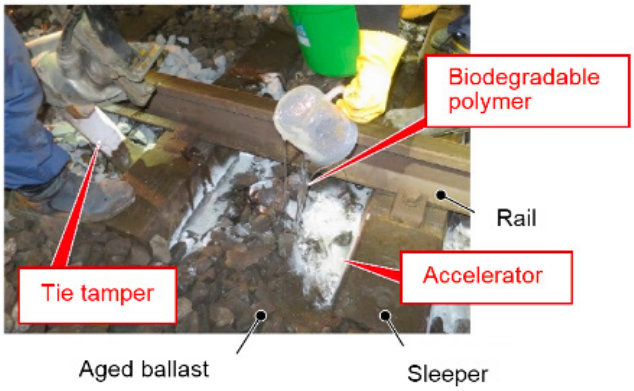


Fig.1 Processing the ballast with biodegradable polymer

【Effects】

This method has already been applied to more than 10 spots of railway tracks for the test purpose. At one rail joint where mud pumping is occurring, the track was subsiding 20mm in three months (Figure 2), but since this method was applied (Figure 3), the ballast has subsided just 10 mm in two years. This data has confirmed that this method has prevented ballast subsidence more effectively than conventional tamping (Figure 4). At this site, tamping had been necessary twice a year. After the method was applied, no tamping has been necessary for two years and it resulted in 30% cost reduction.

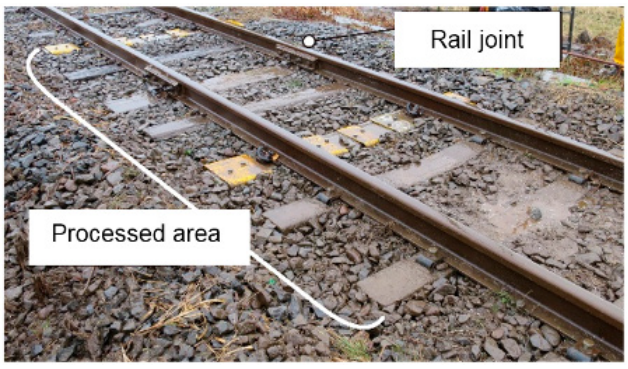


Fig. 2 Before the method is applied

Fig. 3 After the method is applied

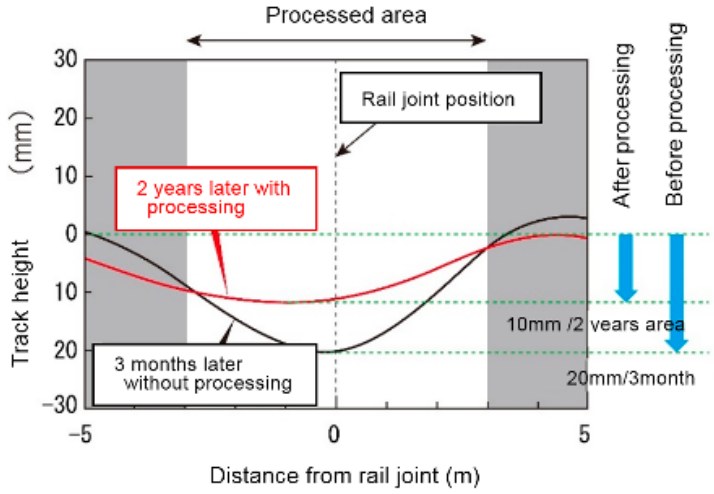


Fig. 4 Effect of the method

【Overview】

In order to fundamentally repair aged, fine-grained ballasted tracks, the ballast needs to be replaced with new one. However, it is difficult to implement such replacement due to its high cost, in particular, on lines with smaller transport amount. Therefore it has been required to develop a low-cost, effective repair method that can be applied to these lines.

With this method, biodegradable polymer and accelerator are poured in ballast that has been finely grained over years and it improves the strength of ballast and mitigates the subsidence of ballasted tracks. Ordinary tie tamping machine is available to apply this method and trains can run on the tracks one hour after the work. The biodegradable polymer (polyvinyl alcohol) and the main ingredient of the accelerator, silicate soda, are commonly used as ground stabilizing materials. Since these materials do not harden the ballast excessively, ordinary maintenance by tamping machines still works after this method applied. As ballast subsidence can be reduced by this method, the tamping interval is extended and as the result, maintenance cost is reduced.

【Work process】

1. The accelerator is tamped in below sleepers by a tie-tamping machine (Figure 5 (a))
2. Biodegradable polymer is poured onto the ballast, then additional ballast is placed, and the sleepers are tamped again (Figure 5 (b))
3. Mixed with fine-grained ballast, the biodegradable polymer gets hardened in a few minutes, the fine grains of the ballast get cemented (stabilized) and stronger, and trains can run on the track within an hour.

The biodegradable polymer used in this system has been marketed by Kowa Kasei Co., Ltd. since March 2018.

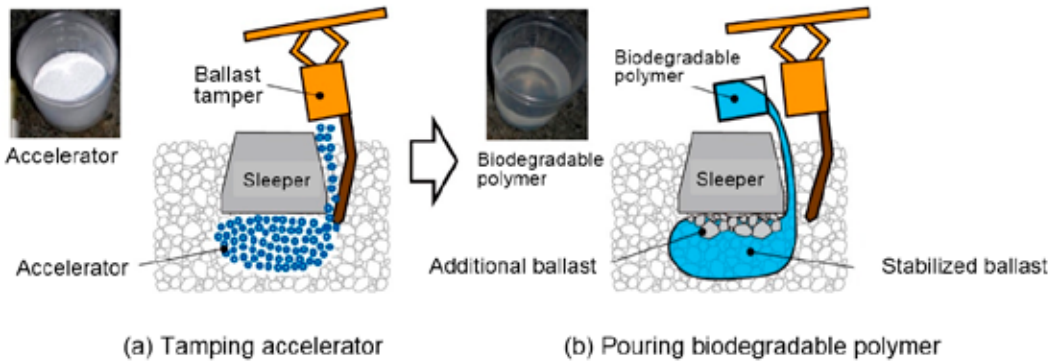
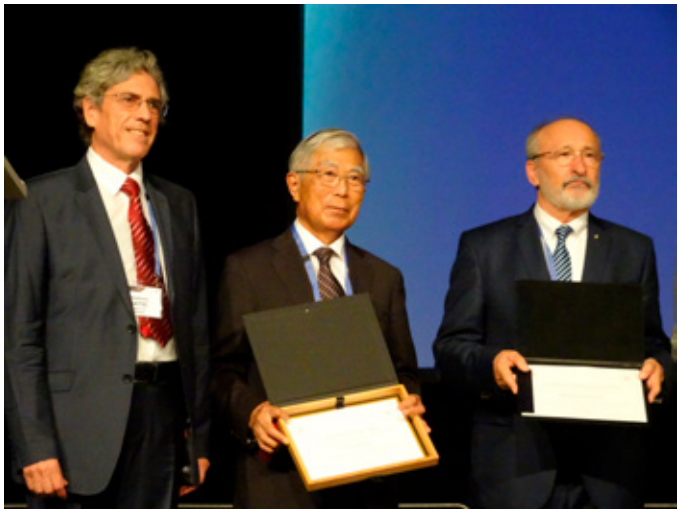


Fig. 5 Work Process of ballast stabilization method using biodegradable polymer

7. Chairman Masada Awarded the Gaston Maggetto Medal from EPE

Dr. Eisuke Masada, Chairman of the Railway Technical Research Institute was awarded the Gaston Maggetto Medal at the 20th European Conference on Power Electronics and Applications (EPE) for his years of contribution to the development of power electronics technology, for the first time as a Japanese. The medal-award ceremony took place on September 18 this year in Riga, Latvia.

EPE is an European conference where researchers and engineers in the field of power electronics gather from around the world. This conference was started in 1985 and its 20th meeting was held this year. The Gaston Maggetto Medal, award of the highest honor given by EPE, was established in recognition of Professor Gaston Maggetto of the Free University of Brussels, who served as the first chairperson of EPE conference and made an outstanding contribution to EPE.



Chairman Masada at the award ceremony

Gaston Maggetto Medal and certificate

8. President Kumagai of RTRI Meets with President of French National Railways

President of the Railway Technical Research Institute (RTRI), Dr. Kumagai, visited the headquarters of the French National Railways (SNCF) and had a meeting with President of SNCF, Mr. Guillaume Pepy, and the executives managing technology-related divisions on the research collaboration.

【Meeting on Japan-France collaborative research】

Date and time: October 18, 2018 14:00 - 14:40
Venue: SNCF Headquarters in Saint-Denis
Attendant:

Norimichi Kumagai	President RTRI
Guillaume Pepy	President SNCF
Dr. Shunichi Kubo	Executive Director RTRI
Pierre Izard	CTO SNCF
David Leborgne	CDO SNCF
Carole Desnost	Director of Research and Innovation Department SNCF

In 1995, RTRI concluded an agreement on research collaboration with SNCF and has implemented collaborative research projects in a number of technical fields. This meeting started with the greetings by both presidents and they shared views on research and development for the highest priority issue, railway safety, and for autonomous railways, energy saving, climate change and human factors. SNCF and RTRI have been promoting projects for digitalization, TECH4RAIL and ICT Promotion Project, respectively. Both presidents confirmed that they need to share the challenges and to cultivate a human network by exchanging personnel. They also talked about WCRR 2019, the World Congress on Railway Research scheduled next year in Tokyo.

Greetings by President Kumagai

It has already been 23 years since the RTRI-SNCF research collaboration started, and we have had many right-to-the-point discussions. Sharing technological expertise by the two most advanced railway organizations means a lot to world's railway systems. I deeply respect the active commitment of SNCF to innovative technologies and President Pepy's policy to emphasize technology. I hope to keep sharing our knowledge and experience in improvement of safety, digitalization, and mitigation of natural disasters over the difference between our railway cultures.

Greetings by President Pepy

I am so pleased that we have been continuing research collaboration with RTRI. I hope we will keep doing in-depth research and learning from each other. We have been addressing the research and development to innovate door-to-door mobility over the years. Since we cannot find ready-made solutions anywhere, we will have to explore them together. Railway industry begins with technology, and then innovation comes along. Of course we always have to see customers beyond the technical innovation, but technology comes first.

Meeting of RTRI and SCNF executives

President Pepy and President Kumagai

9. The 8th SNCF-RTRI Collaborative Research Seminar held in Paris

The Railway Technical Research Institute and SNCF held the 8th collaborative research seminar from October 17 to 19 this year in Paris.

RTRI and SNCF concluded an agreement on collaborative research in 1995 and, since then, have been collaborating in many technical fields of research. This seminar was organized to present the result of each project and to have a management meeting where the plan and schedule of the next-phase projects are set. The seminar took place at the SNCF headquarters in Saint-Denis and its Innovation and Research Division in Bercy, Paris and was attended by 20 people including Mr. Pierre Izard, Vice President, and Ms. Carole Desnost, Director of Innovation and Research of SNCF and President Kumagai and General Director Kubo from RTRI.

(1) Collaborative Research Seminar

At the seminar at the Innovation and Research Division, the representatives of both organizations delivered keynote speeches and the researchers made presentations on the results of 8 current-phase collaborative research projects and the research plans for the 11 next-phase projects.

The keynote speeches were made by Mr. Valéry Versailles, Head of Department, Physical Railway System of SNCF, and Dr. Shunichi Kubo, General Director of RTRI. Mr. Versailles presented the research and development policy of SNCF including three goals: catching up latest technical trend, achieving technical breakthrough and proposing new business model. General Director Kubo introduced the latest results of RTRI's technical development mainly focused on improving safety.

Participants to the seminar

Presentation at the seminar

In the presentation of the 8th-phase project “Predictive maintenance methods of OCS,” a method to predict the wear of contact wire and the possibility of applying it to predictive maintenance for contact wire was presented.

As a 9th-phase research plan regarding digitalization of railways, the researchers reported that they will share information on the research into on-board train position detection and trouble detection technologies.

At the end of the seminar, the representatives of both parties signed the minutes describing what was agreed.

The participants took tours to the Technicampus (training center) and Centre d’ Ingénierie du Matériel (vehicle technology center) of SNCF in Le Mans and had discussions with the engineers there.

Mr. Valéry Versailles and Dr. Furukawa signing the minutes

(2) Management meeting

Vice President Izard and President Kumagai joined the management meeting and the status of research and development on digitalization of railways was reported by both sides. SNCF introduced the outline of the TECH4RAIL project promoted since 2010 and RTRI reported the activities of its ICT Innovation Project. SNCF and RTRI agreed that they will focus on the following four topics and confirm the progress, having a management meeting every year.

①Autonomous railway operation
Obstacle detection
Operation control
From human to machine: which will ensure safety? (AI)
②Natural disaster, climate change (typhoon, heavy rain and flood)
③Energy
④Human factor and safety

The next collaborative research seminar and the management meeting will be held in the fall of 2020 and in the summer of 2019 respectively, both in Japan.

Participants to the management meeting

Management meeting

10. The 58th ICE/TC9 Plenary Meeting Held in Tokyo

The 58th Plenary Meeting of the IEC (International Electrotechnical Commission)/TC9 (Electrical Equipment and systems for railways) (IEC/TC9) took place from November 19 to 22 this year at the Station Conference Manseibashi in Tokyo. The Railway Technical Research Institute (RTRI) has served as the Japanese national mirror committee for IEC/TC9 and organized the Plenary Meeting in Japan as a host country committee.

51 people participated in the meeting from 13 countries, Australia, China, Czech Republic, France, Germany, Indonesia, Italy, Korea, Luxembourg, Russia, Sweden and the United Kingdom.

At the meeting, committee chairperson Mr. Gianosvaldo Piana Fadin expressed gratitude to the host country Japan and called the meeting to order.

Following Mr. Fadin's remarks, Dr. Norimichi Kumagai, president of RTRI, gave welcome remarks.

At the plenary meeting, the conclusions attained through the standardizing activities in the year and the progresses of projects are to be confirmed, and decisions are made to start the review of new standards and to set up the review system.

At this year's meeting, the progress of reviews was reported and discussions were made on starting new projects. Finally 40 resolutions were made including the decisions to start vote for the proposal by Japan, standardizing "AC power compensator", and to set up a new group led by Japan to standardize "lithium-Ion battery for auxiliary circuit."

As you may see, decisions were made to start the review process of new standards where Japan will take the lead. In addition, since many of Japanese experts participated in the meeting and directly explained the review activities in Japan, they were able to appeal the role of Japan in international standardization to the participants from the increasing number of countries. RTRI will use the results of this meeting in order to deepen understanding of Japanese railways and to help Japanese railway technologies advance into overseas markets. During the meeting period, a technical tour to the test facilities at RTRI was organized so that the participants from foreign countries can understand Japanese railway technologies.

IEC/TC9 58th Plenary Meeting

President of RTRI Dr. Kumagai welcoming participants

【Greetings by President Kumagai】

I would like to thank you for participating this plenary meeting held here in Japan, and I want to extend my warmest welcome to you all. All of us at RTRI hope to produce significant results through the review process of international railway standards and to contribute to creating better railway systems in the world. Although technical development and standardization efforts seem two different matters, the goal of both activities, providing the results of serious efforts by researchers and engineers to the society, is based upon the same principle. I am expecting thorough discussion at this meeting that will help building a better world.

Participants of the IEC/TC9 58th Plenary Meeting

Technical tour at RTRI

11. RTRI's Researchers win the UIC Global Research & Innovation Awards 2018

Three of RTRI's researchers won the **UIC Global Research & Innovation Awards 2018**.

In 2012, UIC started to provide these awards to outstanding rail engineers and researchers. UIC's International Rail Research Board (IRRB) took initiative in creating these awards in order to develop and enhance railway transportation at the global level and make it more attractive, cost effective and sustainable. The review committee for the awards consists of IRRB members and the awards are given to researchers and engineers for their innovative work in six main categories of "Safety and Security" "Sustainable Development" "Rail systems technology" "Rail Freight Service" "Passenger Service" and "Cost Reduction." In addition, the Award for the Best Young Researcher and Award for Lifetime Achievement in Research & Innovation are given to a researcher of age under 30 and to a person who has contributed to railway services for many years.

This year's award ceremony took place on December 7 at the UIC Headquarters in Paris and the following three researchers of RTRI attended the ceremony and were given the awards.

Award Ceremony

Date and time :December 7, 2018 16:00
Venue :UIC Headquarters in Paris
Award winners from RTRI

○ Safety & Security Award
"Development of Algorithms for Earthquake Early Warning System Using Ocean Bottom Seismic Network"
Masahiro Korenaga
Assistant Senior Researcher, Seismic Data Analysis Center for Railway Earthquake Engineering Research

○ Sustainable Development Award
"Prediction for Long-term Behaviour of Railway PC Girders affected by Creep and Shrinkage of Concrete"
Ken Watanabe
Senior Researcher, Concrete Structures, Structures Technology Division

○ Cost Reduction Award
"Development of Contactless OCL Geometry Measurement System"
Itaru Matsumura
Assistant Senior Researcher
Current Collection Maintenance, Power Supply Technology Division

By courtesy of P. Fraysseix at UICceremony

Award ceremony
Mr. Matsumura (right end), Mr. Watanabe (fourth from the right), Mr. Korenaga (fifth from the right)

12. The 4th Japan-UK Track Maintenance Workshop Held in Winchester, UK

On November 22, 2018, the Railway Technical Research Institute and University of Southampton held the 4th Workshop on Track Maintenance between UK and Japan in Winchester, UK.

Since 2013, RTRI started to hold Japan-UK workshop on track maintenance in order to pick up issues shared by Japan and UK and develop them into future joint research projects. This year's workshop, the 4th one, was held at Wessex Centre of Winchester Cathedral in Winchester and 35 persons from RTRI, 6 universities of UK and Japan and 2 rail operators from Japan participated. They had discussions regarding issues of railway tracks including high-speed rail track.

The workshop was started by the welcome greetings by Professor William Powrie of Univ. of Southampton, and followed by 8 presentations from UK side and 7 from Japan side, total 15 presentations. The topics of presentations by UK included track maintenance of HS1*1, the research into fiber-reinforced trackbed ballast , test equipment for railway track, and track design considering the construction of HS2*2. The presentations by Japanese researchers dealt with maintenance of Shinkansen, mechanical properties of ballast and track vibration.

Through the presentations, they shared information regarding the latest research output on ballasted track and slab track. The workshop was closed by the remarks by Dr. Momoya, Head of Track Structures and Geotechnology Laboratory, and Prof. Powrie and they agreed that ballasted and slab track maintenance and high-speed rail design are important issues shared by both countries and they will continue sharing information.

Outline of Prof. Powrie's opening remark:

This is the 4h of the UK-Japan track maintenance workshop. At the first workshop mainly the topics regarding ballasted track were dealt with, but since the 2nd workshop, we have picked up issues on high-speed rail and slab track. In the U.K., HS2 project is currently going on and it has been discussed which of ballasted or slab tracks should be adopted for HS2. At this workshop, 15 presentations will be made including that issue. I am looking forward to productive discussions.

Outline of Dr. Momoya's closing remark:

Today, we had presentations covering a wide range of issues on ballasted and slab track. UK and Japan share the technical issues of both types of tracks and the issues need further research and development. I would like to propose that the next workshop be held in 2020, at RTRI or the Univ. of Leeds.

Outline of Prof. Powrie's closing remark:

This has been a very interesting workshop with many presentations on ballasted track maintenance, high-speed line design, noise and vibration, We hope to keep in touch with Japanese researchers toward 5th workshop.

*1 HS1: High Speed One
A high-speed railway line in UK connecting the Channel Tunnel and Saint Pancras Station in London.

*2 HS2: High Speed Two
A high-speed railway line planned in UK following the opening of HS1. The first-stage line is to be opened in 2026, connecting London and Birmingham.

Prof. Powrie making an opening remark

Dr. Momoya making a closing remark

13. Japan-France Workshop on Scour and technical standards for basic structures Held in France

The Railway Technical Research Institute and the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) held the Workshop on Scour and Erosion from November 27 to 29, 2018 in France.

Since 2014, RTRI and IFSTTAR have been implementing collaborative research and exchanging researchers and in 2017, concluded an agreement on collaborative research.

Currently, following three collaborative research and information sharing projects are in progress:

- Analysis of scouring at river bridge base and soil erosion
- Comparison of Japanese and French technical standards for base and soil structures
- Information sharing on the methods to analyze ground-structure dynamic interaction

This workshop took place at IFSTTAR in Marne-la-Vallée in the suburbs of Paris, with 30 participants from RTRI, IFSTTAR, Japanese and French universities, research institutes and railway operators. This was organized to share the results of RTRI-IFSTTAR collaboration and the expertise of railway operators in France and Japan.

The three-day workshop was started by the opening remarks by Mr. Kovarik, Deputy General Director of IFSTTAR, and Dr. Ota, Director of the Disaster Prevention Technology Division of RTRI. From France, 8 presentations were made on its risk management project for scour “SSHEAR”*, on-site scour risk management, big data analysis regarding scour and others. From Japan, 7 presentations were delivered regarding Japan-France comparison of methods to identify scouring risk points, scour monitoring technologies and examples of scouring disasters. Discussions were also made regarding scour and erosion risk management and technical standards for base and soil structures.

With regard to bridge base scouring, examples of scouring and inspection methods were presented as well as RTRI’s scoring tables, scour guidelines in France and the results of comparison and confirmation, followed by productive discussions on the difference between bridge structures, riverbed, flow speeds and inspection methods in Japan and France. The presentations and discussions provided us good suggestions for the improvement of scour risk scoring tables. In the field of technical standards for base structures, the difference and common points between Japan and France in vertical pile-loading tests were reviewed as an information sharing project.

Outline of Mr. Kovarik’s opening remark:

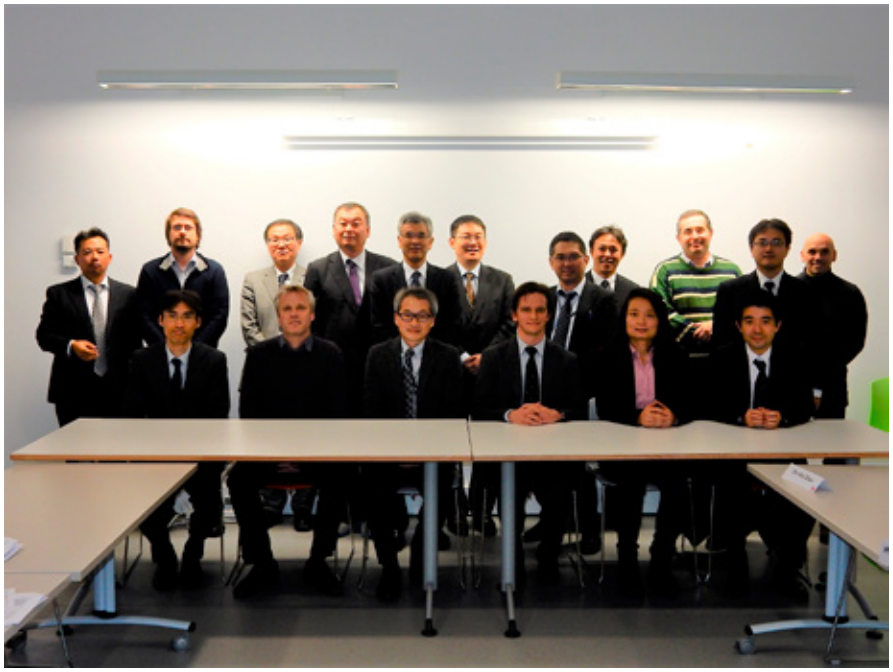
RTRI and IFSTTAR have been working together to share our expertise and improve the quality of research activities for the purpose of making railway systems more resilient, friendly to the environment and fitting to climate. In this workshop, we will be focusing on the research into scouring at bridge base and relationship between erosion and soil properties. I hope researchers from both sides will have discussions and promote the projects beyond a meeting room.

Outline of Dr. Ota’s opening remark:

This workshop will provide us a very good opportunity to understand the difference between France and Japan in scouring and eroding risk by sharing our expertise. I am looking forward to having even closer cooperative ties with IFSTTAR, related universities and institutes through this workshop.

* Soils, Structures & Hydraulics Expertise and Applied Research

Deputy General Director Kovarik



Participants

Vision

We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society.

Missions

We will accomplish the following three missions:

To intensify research and development activities so as to improve railway safety, technology and operation, responding to customers'needs and social change.

To develop professional expertise in all aspects of railways and, as an independent and impartial research body, to fulfil our tasks using the best science available in an ethical way.

To pioneer cutting-edge technologies for apanese railways and become a world-leader.

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